PARADISE CREEK TMDL

WATER BODY ASSESSMENT AND TOTAL MAXIMUM DAILY LOAD

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1.0 EXECUTIVE SUMMARY

Paradise Creek flows from its headwaters on Moscow Mountain in the Palouse Range through the City of Moscow and across the Washington State line to the South Fork of the Palouse River near Pullman, Washington. In 1994, Paradise Creek was identified as water quality limited from its headwaters to the Washington State line for the following pollutants: ammonia, nutrients, sediment, habitat modification, pathogens, flow alteration, and temperature.

Section 303(d) of the Federal Clean Water Act requires States to develop a Total Maximum Daily Load (TMDL) management plan for water bodies determined to be water quality limited. A TMDL documents the amount of a pollutant a waterbody can assimilate without violating a state's water quality standards and allocates that load capacity to known point sources and nonpoint sources. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety and natural background conditions.

The Idaho Water Quality Standards designate cold water biota, secondary recreation and agricultural supply as beneficial uses for Paradise Creek. The DEQ Beneficial Use Reconnaissance Project (BURP) was conducted on Paradise Creek in 1994, 1995 and 1996. The BURP data was analyzed using the Water Body Assessment Guidance (WBAG) document (IDHW-DEQ, 1996). The analyses indicated that Paradise Creek is not providing full support of beneficial uses because of macroinvertebrate population impairment and exceedances of water quality standards.

Interstate waters, such as Paradise Creek are required by the Clean Water Act to meet the receiving state's water quality standards at the state line. Washington water quality standards classify Paradise Creek as a Class A water to be protected for salmonid spawning, primary contact recreation and domestic uses along with uses such as water supply, wildlife and aesthetics. Salmonid spawning, primary recreation and domestic water supply are not supported for Paradise Creek (EPA, 1993).

The primary nonpoint sources (NPS) of pollutants in the Paradise Creek watershed are non-irrigated croplands, grazing lands, land development (construction activities), urban runoff, roads and forest land harvest activities. Permitted point sources of pollution include the Moscow wastewater treatment plant (MWWTP) and University of Idaho's (U of I) aquaculture facility. Storm water discharge systems and several other discrete sources are included with the more traditional nonpoint sources for loading analysis due to a lack of data and methodology for separate evaluation.

In the winter and spring Paradise Creek is typically affected by suspended solids from eroding agricultural fields during high runoff. During the low flows of the late summer phosphorus and nitrogen are present in high enough concentrations to stimulate algal and macrophyte populations. The respiration cycles of these algal and macrophyte populations may then cause large diurnal and seasonal fluctuations in dissolved oxygen concentrations, leading to depletion of dissolved oxygen concentrations during the late summer low flow periods. Nutrient and bacteria levels often exceed both Idaho and Washington standards. Due to discharge from the MWWTP, ammonia levels at the state border compromise many of the beneficial uses of a Washington Class A waterbody.

Water quality standards for the states of Idaho and Washington are intended to provide protection of designated beneficial uses. TMDL targets are based on these water quality standards. Numeric water quality standards are used where they exist. Narrative water quality standards have been interpreted and applied to Paradise Creek for sediment and nutrients. A numeric total suspended solids (TSS) target was determined based on Idaho Water Quality Standards for turbidity and a correlation between turbidity and the TSS measured within Paradise Creek. A numeric total phosphorous target was determined based on Idaho Water Quality Standards for excess nutrients and nuisance algae growth. The background phosphorous concentration measured in an area of Paradise Creek absent of algae growth was selected as the numerical target. These numeric targets are intended to provide protection of designated beneficial uses.

Load capacities reflect these water quality targets for Paradise Creek. Load allocations presented in this TMDL are based on the load capacities developed using these targets. Targets, loading analyses, and load allocations are presented for sediment, total phosphorus, temperature (thermal modification), bacteria (pathogens) and ammonia. Loading analyses indicate that the estimated load capacities for these pollutants in Paradise Creek are currently exceeded, and therefore, require reductions. Proposed reductions vary by pollutant and source and are summarized in table

Idaho State Water Quality Standards apply throughout the Paradise Creek Watershed. Data used in calculating Paradise Creek's load capacity were collected at the United States Geological Survey (USGS) flow station and the MWWTP approximately 1/4 mile upstream of the Idaho-Washington state border. Pollutant allocations and reductions are based on the load capacity estimated at this point. Compliance with these targets apply within Paradise Creek at the Idaho-Washington border.

An implementation plan will be developed by the Paradise Creek Watershed Advisory Group and supporting agencies to specify controls designed to improve Paradise Creek water quality by meeting the load-allocations contained in this TMDL document. During implementation additional water quality information is expected to be generated. In the event that new data indicate that the targets used in this analysis are not appropriate, the load capacity would be adjusted accordingly. Because targets will be re-examined and potentially revised in the future the Paradise Creek TMDL is considered a phased TMDL.

2.0 WATERSHED ASSESSMENT

WQ CONCERNS AT A GLANCE:

Water Quality-Limited?	*Yes*
Segment Identifier:	*PNRS #1135*
Parameters of Concern:	*Ammonia, Nutrients, Sediment, Habitat Alteration, Pathogens, Flow, Temperature*
Uses Affected:	*Secondary Contact Recreation, Agricultural Water Supply, Cold Water Biota*
Known Sources:	*Point Sources-Sewage Treatment Plant, Aquaculture Facility NPS-Agriculture, Urban, Forestry*

2.1 WATERSHED CHARACTERIZATION

General Description

Paradise Creek (PNRS # 1135) is located in the Palouse River hydrologic basin. The headwaters of the creek are located on Moscow Mountain in the Palouse Range, with the creek flowing in a southwesterly direction for approximately 19 miles, through the City of Moscow, Idaho, ultimately joining the South Fork of the Palouse River in Pullman, Washington.

The Paradise Creek Watershed is 23,038 acres in size with 13,888 acres located within Idaho; the other 9,150 acres are located in Washington state (USDA, 1995). The upper portion of the watershed is steeply sloped, with the majority of the drainage basin consisting of moderately steep rolling hills. Elevations range from 4,356 feet at Paradise Point in the Palouse Range, to 2,520 feet at the Idaho-Washington border. The Palouse hills are very susceptible to erosion due to their topography, soil texture, and land use practices which result in a lack of vegetative cover during the period of maximum precipitation (November-March)(USDA, 1995). The lower half of the watershed in Latah County lies between 2500 and 2700 feet and rises to maximum height in the Palouse Range to the east. Very little local relief occurs in the lowland areas; beginning at 2900 feet elevations rise rapidly and change dramatically once in the Palouse Range. Slope distribution is outlined in Figure 1.

Hydrology

Paradise Creek is a fourth order stream comprised of 55 stream segments. Of the 55 stream segments, 49 flow through agricultural fields (Doke and Hashmi, 1994). Paradise Creek is characterized as a youthful stream with indistinct drainage channels and little topographic relief

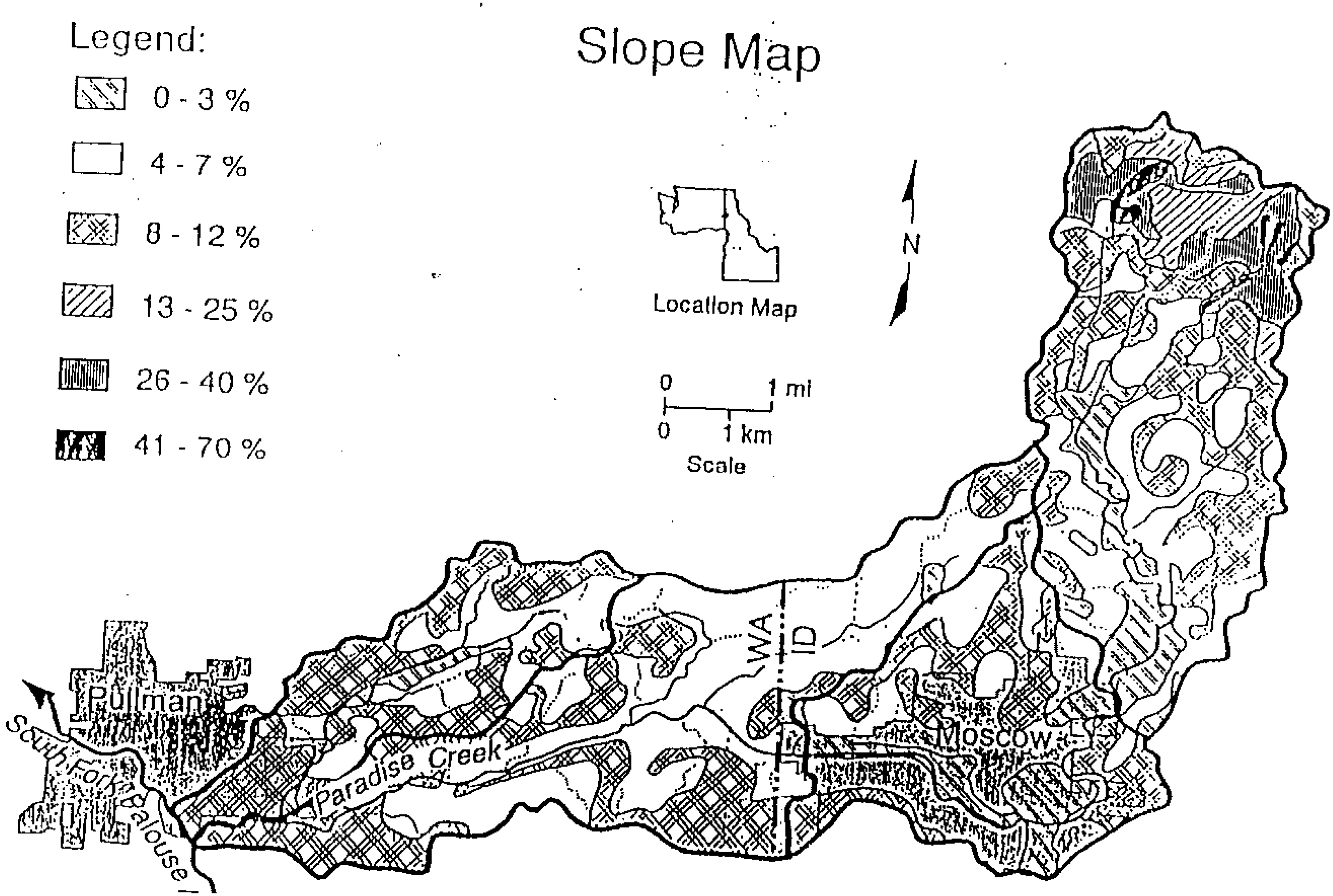


Figure 1. from Doke and Hashmi (1994)

between adjacent drainage basins. The small and scattered wetlands within the watershed further characterize Paradise Creek as a youthful stream. The morphology of the stream channel is "v" shaped as it runs down Moscow Mountain and rectangular through much of the lowland agricultural areas. Where Paradise Creek runs through agricultural fields, the streambank becomes highly unstable and susceptible to channel erosion due to the fine loess soil and present lack of vegetation along its banks.

Daily flow data is taken at the USGS gaging station located on Paradise Creek 0.2 miles upstream from the MWWTP. The Paradise Creek annual runoff hydrograph is characterized by low flows during the summer and fall seasons and peak flows during the winter and spring seasons. Precipitation within the Paradise Creek watershed is highest during December and January where the precipitation is either snow or a combination of rain and snow. During the spring months, the winter snowpack melts causing prolonged high flows. Rainfall onto frozen soils and rainfall coinciding with snowmelt typically cause peak flows within the watershed.

Mean monthly flow values for peak months are highly variable from year to year, ranging from 4 cfs for January, 1994 to 104 cfs for February. Daily average flows for peak flow months range from less than 1 cfs (1/31/94) to 755 cfs (2/8/96). From June through October, flows are very low, averaging 1.35 cfs during this five-month period; average monthly flows have dropped as low as 0.21 cfs during September (USGS, 1986 to 1996).

Water does not flow in all of Paradise Creek's sub-basins throughout the year. Above Moscow, Paradise Creek is intermittent, running for several months from the spring thaw until May or June. In the summer, flow reaches zero, reducing the stream to a series of small pools separated by stretches of dry creek-bed. Paradise Creek typically freezes, thaws, and re-freezes several times during the winter, at times resulting in intermittent flows during the months of November to March as well.

USGS mapping shows Paradise Creek as perennial from Main Street (US 95) downstream. Doke and Hashmi (1994) have identified the 7Q10 flow (the lowest flow occurring for a period of seven days in a 10 year period) as 0.3 cfs for Paradise Creek approximately 0.2 miles above the MWWTP and as 3.79 cfs for the MWWTP. Kjelstrom, Stone, and Harenberg (1995) identify 7Q10 flow as 0.10 for Paradise Creek based on 1980 to 1990 data from the USGS gaging station. At 7Q10 flow, the MWWTP contributes nearly all flow. Kjelstrom, Stone, and Harenberg (1995) identified 7Q2 flow as 0.20 cfs.

Wetlands in the watershed are typically associated with the riparian areas along Paradise Creek and its tributaries. Wetland areas in the watershed can be classified as palustrine and riverine in nature. Natural vegetation is dominated by the introduced reed canary grass, in addition to the native sedges, willows, and alder. The condition of the area's wetlands are rated as poor to fair due to past and present management activities (Doke and Hashmi, 1994).

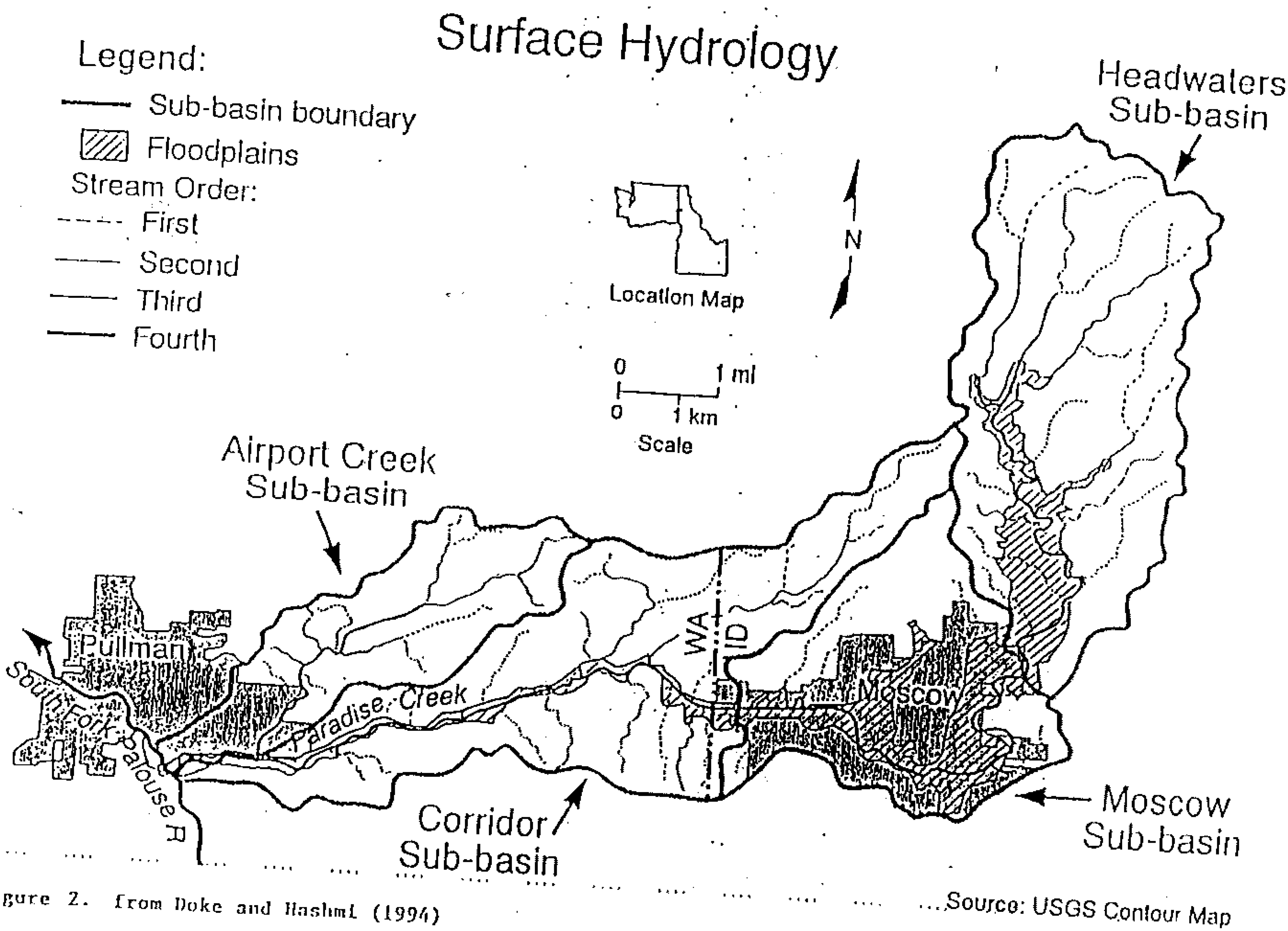
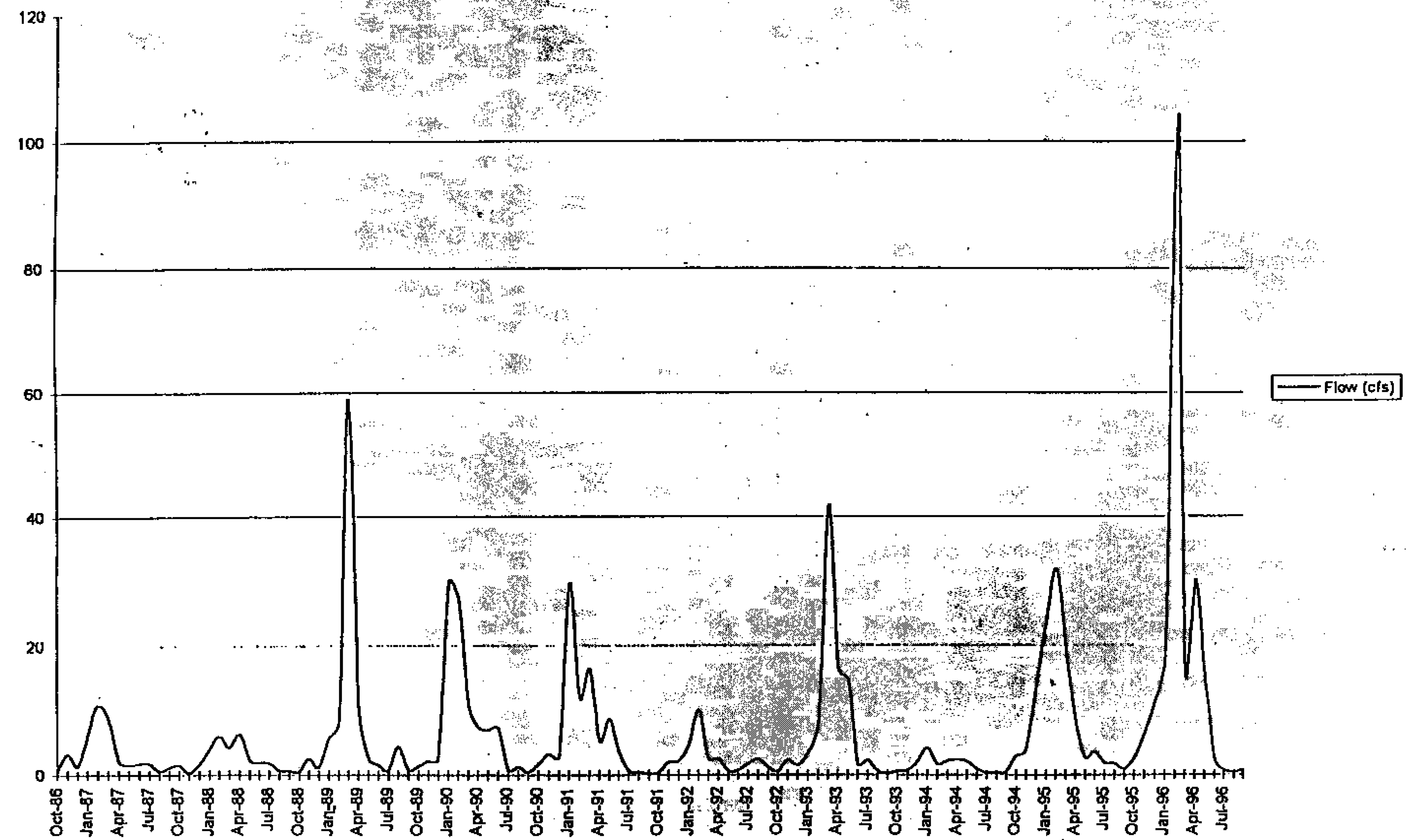


Figure 2. from Doke and Hashmi (1994)

Figure 3. Paradise Creek Mean Flows (Oct 86 to Sept 96)



Climate

Average annual precipitation in the Paradise Creek Watershed is approximately 23 inches, with an average snowfall of about 48 inches; the uppermost portion of the watershed experiences the most precipitation. Nearly 40 percent of annual precipitation falls as rain and snow during November, December, and January. Much of the winter precipitation is in the form of rain which thaws the frozen soil surface. This shallow thawing creates rapid runoff from the area's non-irrigated cropland since the soil remains frozen below the surface and prevents infiltration. July and August are the driest months and period of greatest evaporative moisture loss; precipitation, if any, usually occurs as brief thunderstorms (Doke and Hashmi, 1994).

Mean daily temperatures range from a low of approximately 28°F in January to a high of 66°F in July, with an average annual daily temperature of about 47°F. The average January minimum temperature is 5°F, while the average July maximum temperature is 96°F. Summers are typically hot and dry, with daily temperatures sometimes reaching 100°F; nightly temperatures can drop to 30°F (Doke and Hashmi, 1994).

Geology

Paradise Creek Watershed is in the Palouse Hills section of the Columbia Plateau Geomorphic Province (John Bush, 6/97). Bedrock consists predominantly of Tertiary age Columbia River Basalt. Lake and stream deposits of clay, silt, sand, and gravel form interbeds between the basalt flows; in addition, similar sediments overlie the basalts. These sediments are referred to as the Latah Formation; the uppermost sedimentary unit overlying the basalts are called the sediments of Bovill. Cretaceous age Idaho Batholith granitic rocks form the Palouse Range on the extreme north and northeast part of the watershed, in the headwaters area. Intruded by the granitic rocks are Precambrian age meta-sediments of the Belt Supergroup which are predominantly quartzite, schist, and gneiss. The watershed area is typified by rolling asymmetrical hills of the Quaternary age Palouse Formation. Quaternary age eolian (windblown) and alluvial (stream) deposits are found along the stream drainages and on the surface of the lower hills throughout the watershed.

In addition to the younger Palouse Formation, the Miocene sediments of Bovill are a source for fine grained transported material that is characteristic of the Paradise Creek drainage. Approximately 15 million years ago, the Columbia River Plateau was covered by a group of basalt flows belonging to the Priest Rapids Member of the Wanapum Formation. In the Moscow area, these flows went over a thick sediment sequence (Vantage Member of the Latah Formation) that now separates the Priest Rapids unit from the earlier Grande Ronde flows and sediments of Moscow. Along its eastern margin, emplacement of the Priest Rapids flows created a raised base level and caused deposition of kaolinitic clay, quartz sand and minor gravel from nearby weathered basement rocks by streams. These sediments, referred to as the sediments of Bovill, form a westward thinning wedge over much of Moscow between the overlying loess and underlying basalt flows, and in places lie directly on weathered crystalline rocks.

Paradise Creek Geology

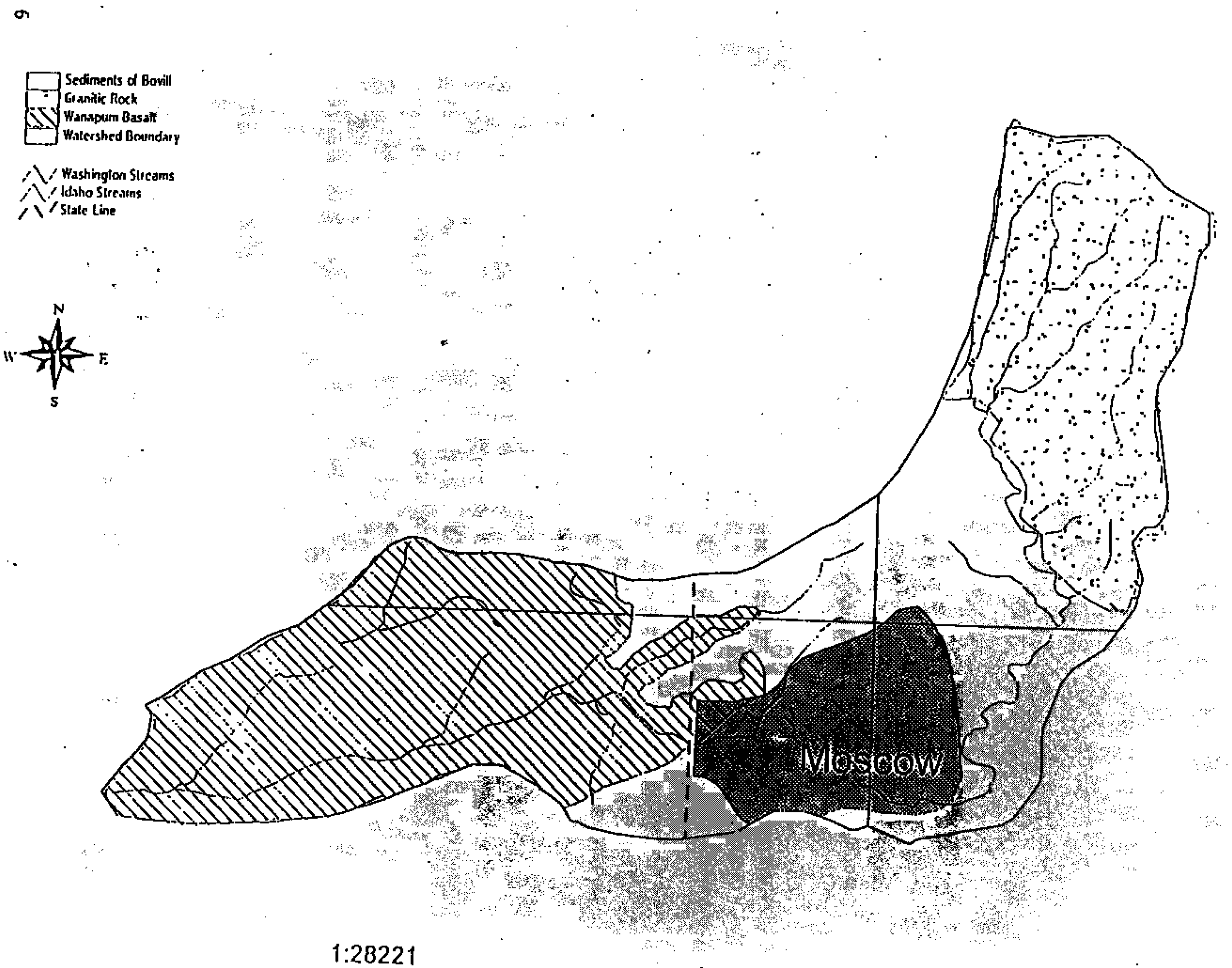


Figure 4.

Along the basement-basalt contact, sediments of Bovill consist of poorly sorted, conglomeratic, micaceous sands interbedded with kaolinite-rich clays. Over the western end of Moscow these sediments are dominated by clays with minor interbedded lenses and locally laterally continuous units of sands and silts. The sediments of Bovill (Figure 4) lie beneath approximately 70% of Paradise Creek's drainage area in Idaho; the western extent of this unit within the watershed ends just past the Washington State line where basalt is exposed at or near the surface. An isopach map (Pierce, 1996) of sand-gravel to clay ratios within these sediments indicate that approximately 70 percent of that portion of the lithologic unit that lies beneath the Paradise Creek channel is comprised entirely of clays, another 23 percent contains greater than 70 percent clay-sized sediment, and the remaining 7 percent contains greater than 30 percent coarser material along the eastern contact with older granitic rocks. Sediments of Bovill as well as granitic basement rocks in the Idaho portion of the Paradise Creek watershed are blanketed in places by the eolian silts (loess) of the Palouse Formation. Alluvium associated with the Paradise Creek drainage is commonly reworked loess or mixtures of loess, basalt and granitoid fragments. Most stream deposits grade laterally into loess (windblown silt) of the Palouse Formation and contain slope wash deposits derived from the loess covered hills.

Paradise Creek is characterized as a youthful to early mature stream. Stream erosion and deposition processes associated with Paradise Creek, in Idaho, have not adjusted to the disruption caused by basalt emplacement and associated deposition of sediments. Loess deposition during the Pleistocene further slowed that adjustment. Deposition of sediments upon near horizontal basalt flows that lapped up against the granitic uplands in the Paradise Creek watershed led to creation of a stream channel with a very gentle gradient (≤0.5%) within most of the Idaho side of the watershed that steepens (7% avg. gradient) rapidly above an elevation of 2700 feet within the upper portion of the watershed (see Figure 1). Paradise Creek's channel steepens moderately from the Washington state line to the creek mouth.

Paradise Creek's relative age, geologic setting and fine grained sediment suggest that the channel is prone to meander within a larger flood plain. A continuously meandering creek located within such a system indicates a naturally high background level of fine grained sediment input to the channel system. This results in a highly sensitive cold water biota habitat.

Soils and Soil Erosion Potential

General soil type distribution is shown in Figure 5. The primary soils types existing in the Latah County portion of the Paradise Creek Watershed are (Doke and Hashmi, 1994):

* Palouse-Naff - very deep, well drained, gently sloping to moderately steep slopes, soils formed in loess.

* Southwick-Larkin - very deep, moderately well drained to well drained, gently sloping to moderately steep slopes, soils formed in loess.

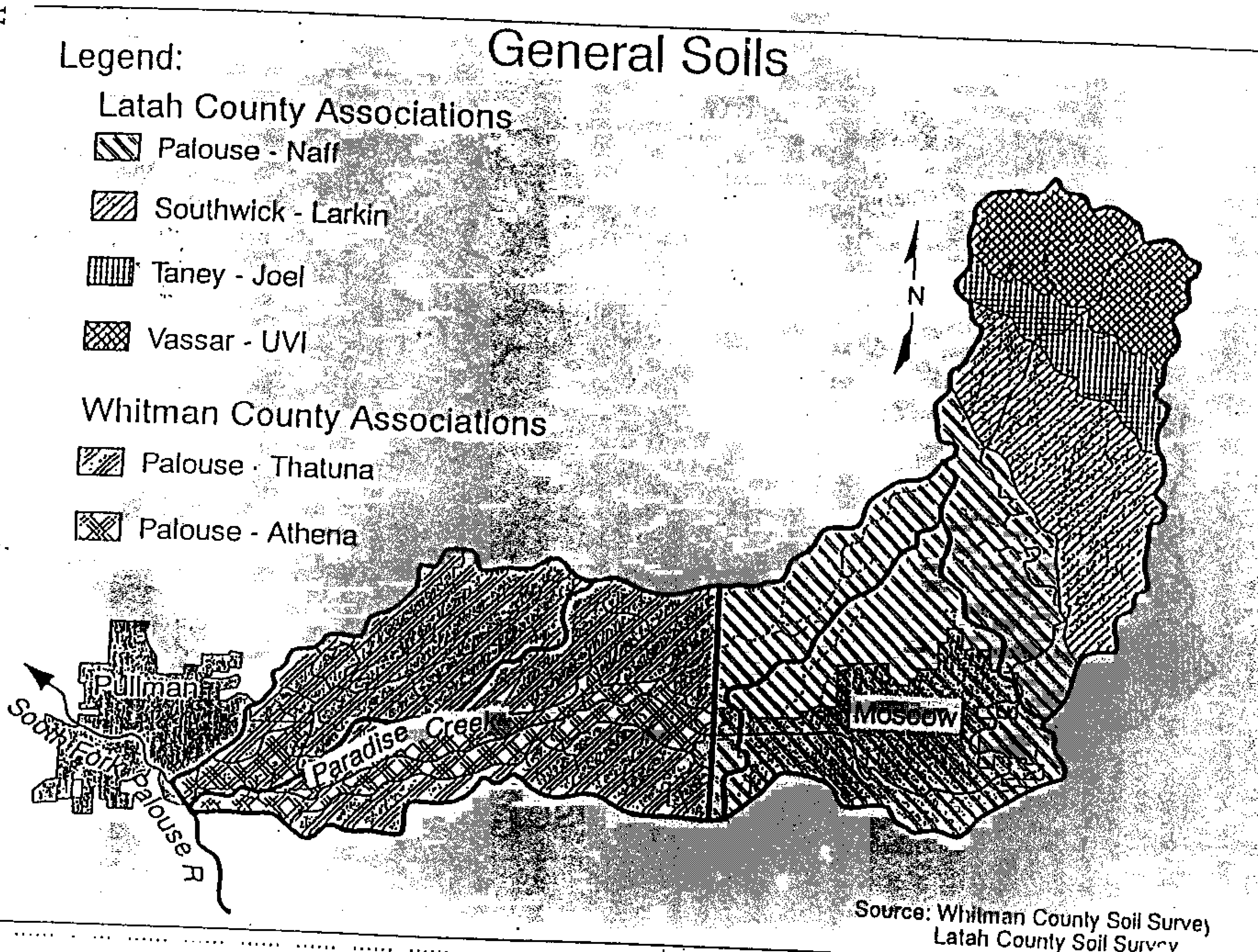


Figure 5. from Doke and Hashmi (1994)

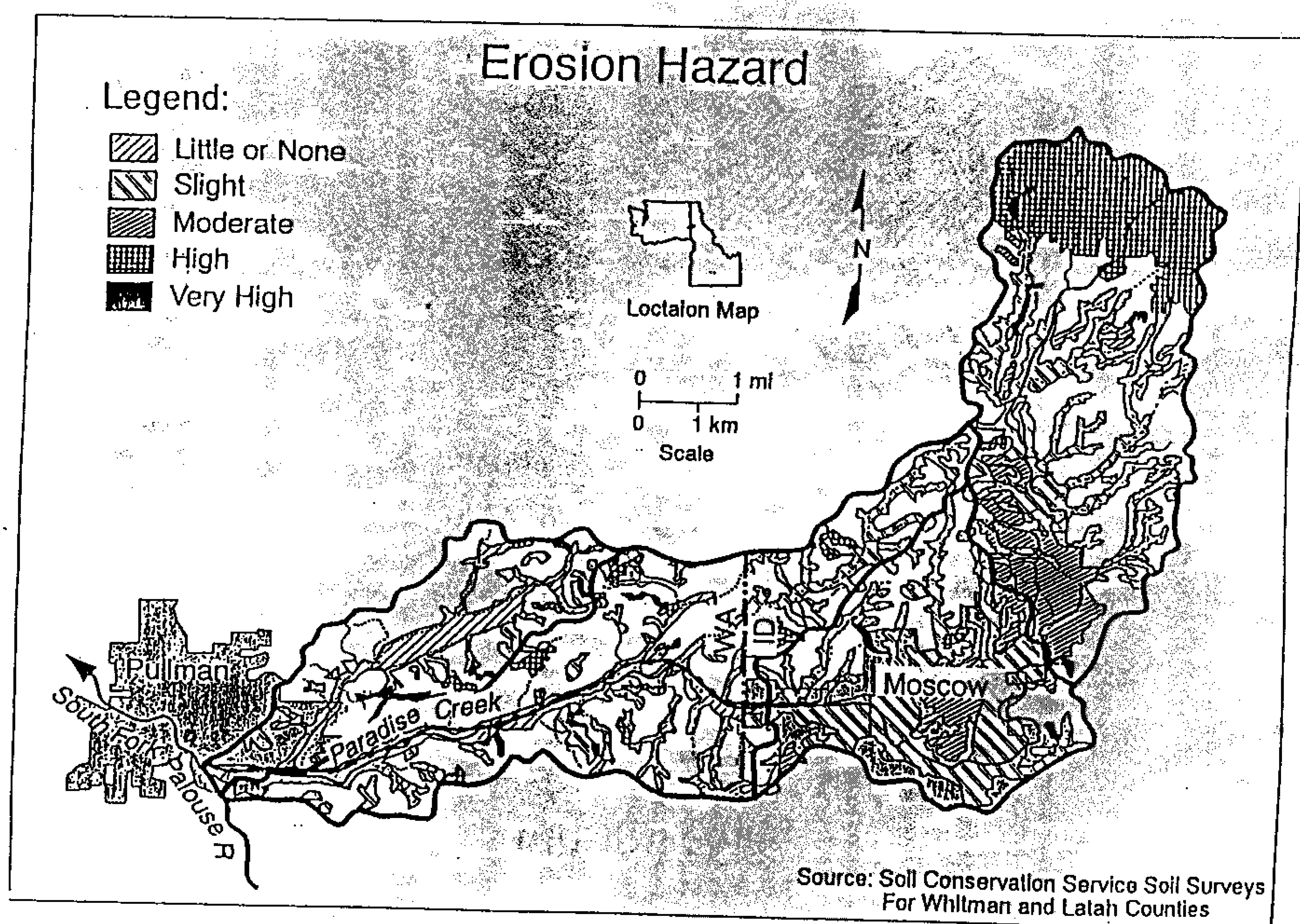


Figure 6. from Doke and Hashmi (1994)

* Taney-Joel - very deep, moderately well drained to well drained, gently sloping to moderately steep slopes, soils formed in loess.

* Vassar-Uvi - deep to very deep, well drained soils formed in volcanic ash, loess and granitic residuum.

Soil erosion is a major concern in the Paradise Creek watershed. Natural landscape shaping processes have been modified and accelerated by agricultural practices. The rolling hills characteristic of the watershed are largely a result of both water and tillage erosion. North and northeast facing slopes tend to be steeper than south facing slopes; this phenomena has been attributed to higher erosion and slump potential on northerly slopes caused by snow drift accumulation (USDA, 1981).

Figure 6 shows erosion potential based on slope and general soil type but does not account for other mitigating factors like vegetative cover, disturbed areas, etc.

Fisheries

Wertz reported that Paradise Creek may have historically supported a trout fisheries (Wertz, 1993). Documentation on the existence of this trout population has not been found. Currently, only cold water biota are present within Paradise Creek (Wertz, 1995). Cold water fish species include: redside shiner, northern squaw fish, large-scale sucker, speckled dace, longnose sucker and bridgelip sucker.

Historical and Present Day Land Uses

The Idaho State Historic Preservation Officer has indicated that known historic or prehistoric cultural resource sites exist in the Paradise Creek Watershed. The Palouse Indians originally inhabited the Paradise Creek area. The first non-Indian settlement likely occurred during the 1860s. By the 1870s Moscow had become a major trade center. Grazing was the first agricultural activity in the area. Dryland farming began in 1877. The coming of the railroad boosted Moscow's population to 2,000 by 1890. Mining and a local fruit industry were short lived abandoned by 1910. Dryland farming survived as the primary resource industry of the watershed (Steiner, 1985).

Moscow is home to about 19,000 people, Latah County seat and cultural center, and is the site of the state's land grant University. The University of Idaho, agriculture, retail trade and service industries are major contributors to the local economy. Historically, the area population has grown at a rate of 1 to 1.5 percent annually but this rate has increased to approximately 4% in recent years (Doke and Hashmi, 1994)

Most of the watershed is privately owned. Land ownership is mixed geographically and not necessarily contiguous. Forest land ownership includes tracts owned by the State of

Idaho, University of Idaho, non-industrial private forest land owners, and private industrial forest product companies.

The predominant land use within the watershed is private non-irrigated cropland. Typical crops produced in the area include wheat, barley, peas, and lentils. There are approximately 20 agricultural operators in the watershed.

In the Preliminary Investigation Report for the Paradise Creek Watershed (USDA, 1995), major land uses were identified as outlined in the following table:

Table 1. Land use distribution within the Water Quality Limited Segment of Paradise Creek.

Land Use	**%**	**acres**
Non-irrigated Cropland	60.5	8403
Forest Land	14.2	1978
Pasture Land	8.6	1200
Urban Land	16.6	2307
Total		**13,888**

Land use distribution is illustrated graphically in Figure 7.

Agriculture is, by far, the largest land use within the watershed. These fields are intensively farmed and fallow for much of the year.

At about 17% of the watershed, designated urban area, though much smaller than agriculture, rates as the second largest land use. Urban areas contains a relatively large and dense population of people, cars and pets, and much impervious ground. Channelization of Paradise Creek has occurred in the urban as well as agricultural portions of the watershed and has been placed underground for about a quarter mile downstream of Line Street. Although these two historical impacts may be unfeasible to reverse, they have contributed to the problems that currently exist within the watershed.

Forested land comprises approximately 14% of the land within the Idaho portion of the watershed. Much of this area has been subject to timber harvest, but at present, there is little timber harvesting or related road building in the Paradise Creek watershed.

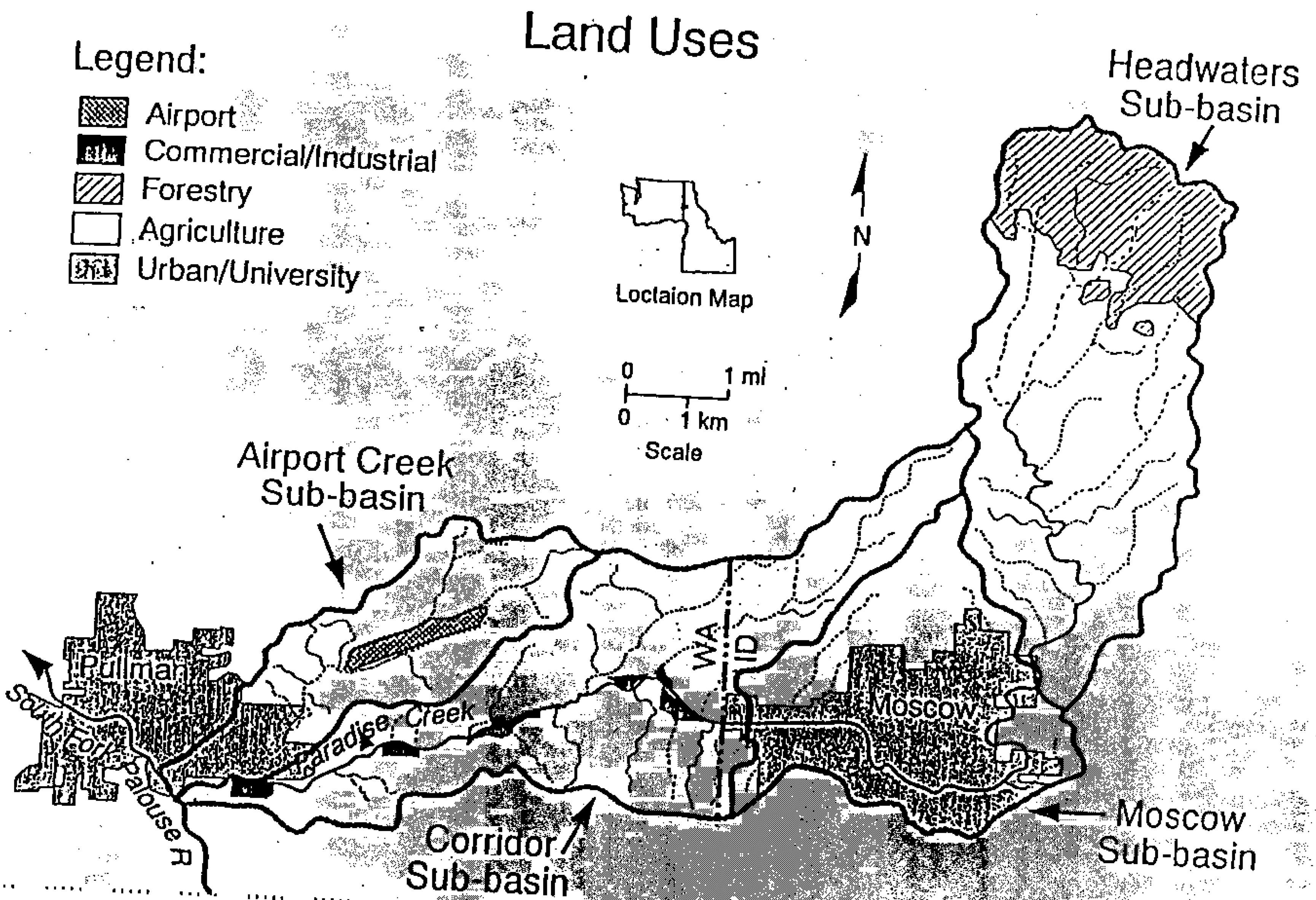


Figure 7. from Doke and Hashmi (1994)

2.2 WATER QUALITY CONCERNS AND STATUS

Paradise Creek is listed for the following pollutants of concern on the 1996 §303(d) list for the state of Idaho: nutrients, sediment, temperature, flow alteration, habitat modification, pathogens, and ammonia. Cold water biota, secondary contact recreation, and agricultural water supply are the designated beneficial uses that require support.

Surface Water Beneficial Use Classifications

Surface water beneficial use classifications are intended to protect the various uses of the state's surface water. Idaho waterbodies which have designated beneficial uses are listed in Idaho's Water Quality Standards and Wastewater Treatment Requirements (IDHW 1996). They are comprised of five categories: aquatic life, recreation, water supply, wildlife habitat, and aesthetics.

Aquatic life classifications are for water bodies which are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species. Aquatic species include cold water biota, warm water biota, and salmonid spawning.

Recreation classifications are for water bodies which are suitable or intended to be made suitable for primary contact recreation and secondary contact recreation. Primary contact recreation depicts prolonged and intimate contact by humans where ingestion is likely to occur. Secondary contact recreation depicts recreational uses where ingestion of raw water is not probable.

Water supply classifications are for water bodies which are suitable or intended to be made suitable for agriculture, domestic, and industrial uses. Wildlife habitat waters are those which are suitable or intended to be made suitable for wildlife habitat. Aesthetics are applied to all waters.

Designated Beneficial Uses of Paradise Creek

Currently Paradise Creek beneficial uses are listed as cold water biota, secondary contact recreation and agricultural water supply (IDAPA 16.01.02).

Water Quality Criteria

Idaho water quality standards include criteria necessary to protect designated beneficial uses. The standards are divided into three sections: General Surface Water Criteria, Surface Water Quality Criteria for Use Classifications, and Site-Specific Surface Water Quality Criteria (IDHW, 1996).

The following water quality criteria are applicable to pollutants of concern as listed on the 1996 303(d) list and uses designated for Paradise Creek:

IDAPA 16.01.02.200.03

Deleterious materials. Surface waters of the state shall be free from deleterious materials in concentrations that may impair designated beneficial use.

IDAPA 16.01.02.200.05
Floating, Suspended, or Submerged Matter. Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities.

IDAPA 16.01.02.200.06
Excess Nutrients. Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.

IDAPA 16.01.02.200.07
Oxygen-Demanding Materials. Surface waters of the state shall be free from oxygen demanding materials in concentrations that would result in an anaerobic water condition.

IDAPA 16.01.02.200.08
Sediment. Sediment shall not exceed quantities specified in Section 250, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.02.b. Subsection 350.02.b generally describes the BMP feedback loop for non-point source activities.

IDAPA 16.01.01.250.01.b
Secondary Contact Recreation: waters designated for secondary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding:

i. 800/100 mg/l at any time; and

ii. 400/100 mg/l in more than ten percent of the total samples taken over a thirty day period; and

iii. A geometric mean of 200/100 mg/l based on a minimum of five samples taken over a thirty day period.

IDAPA 16.01.01.250.02.c
Cold Water Biota, water designated for cold water biota are to exhibit the following characteristics:

i. Dissolved Oxygen Concentrations exceeding 6 mg/l at all times.

ii. Water temperatures of 22 °C or less with a maximum daily average of no greater than 19 °C.

iv. Turbidity below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than 50 NTU instantaneously or more than 25 NTU for more than ten (10) consecutive days.

Flow data collected from Paradise Creek by Schnabel and Wilson (1996) indicates that Paradise Creek is intermittent. Therefore Idaho water quality standards may not apply to some of the upper portions of Paradise Creek during low flow times of the year. Interim targets and water quality standards pertain to those times and locations where Paradise Creek is non-intermittent. The State of Idaho defines an intermittent stream as "a stream which has a period of zero flow for at least one week during most years. Where flow records are available, a stream with a 7Q2 hydrologic-based design flow of less than one-tenth (0.1) cfs is considered intermittent. Streams with perennial pools which create significant aquatic life uses are not intermittent" (IDAPA 16.01.02.003.50). Stream segments of zero flow occur between perennial pools within the upper portions of the Paradise Creek watershed.

Flows within the middle portions of Paradise Creek are typically maintained throughout the year. However, flows recorded during the late summer months can be very low. The monthly average low flow recorded at the USGS Flow station for September for the years 1986 through 1996 is 0.17 cfs. (USGS, 1996). State water quality standards pertaining to point source discharges stipulate that if a designated mixing zone exists in a flowing receiving water "the mixing zone is not to include more than twenty five percent (25%) of the volume of the stream" (IDAPA 16.01.02.060.01.e.iv). Recognizing Paradise Creek flow volumes are not large enough to support an adequate mixing zone during the low flow seasons of the year, TMDL targets and allocations for the Moscow Wastewater Treatment Plant and the University of Idaho Aquaculture facility are applied to the end of the discharge pipe for the purposes of this TMDL.

Interstate Water Quality Requirements

Section 401 of the CWA states that in the case of interstate waters where state criteria differ, the standards of the downstream state must be met at the border. Washington water quality standards classify Paradise Creek as a Class A waterbody (WAC 173-201). Class A waters are to be protected for: domestic, industrial, and agricultural water supply; stock watering; primary contact recreation; aesthetic enjoyment; wildlife habitat; and salmonid and other fish spawning, rearing, migration and harvesting. The EPA has stated that Paradise Creek does not support domestic water supply, salmonid spawning and rearing, and primary contact recreation beneficial uses (EPA, 1993).

The State of Idaho has relied on EPA Region 10 staff to ensure appropriate coordination of interstate water quality concerns have been adequately addressed. EPA Region 10 staff have provided Washington State standards for the Paradise Creek TMDL. These standards are derived from WAC 173-201A-030 and include:

- Dissolved oxygen concentrations must meet or exceed 8.0 mg/l.
- Temperature shall not exceed 18 °C.
- Fecal coliform shall not exceed a geometric mean concentration of 100 fecal coliform/100 ml.
- Turbidity must not exceed 5 NTU over background when background turbidity is 50 NTU or less, or have more than a 10 percent increase if the background turbidity is greater than 50 NTU.

The Washington water quality turbidity standards are very similar to the Idaho's standards for turbidity. Therefore, the use of Idaho's water quality turbidity standards as the basis for a correlated TSS sediment target is assumed to provide assurances that the sediment target will meet Washington State water quality standards within Paradise Creek. Washington standards state that turbidity shall not exceed 5 NTU over background when background is 50 NTU or less, or have more than 10% increase in turbidity when the background turbidity is more than 50 NTUs. The EPA considers application of this standard to the point sources and nonpoint sources found in Paradise Creek to allow 5 NTUs to be added by each source of sediment load. Application of a 5 NTUs increase over background to each of the five sources identified (forestry, agriculture, storm water, waste water treatment plant and, aquaculture facility) provides a total of 25 NTUs above natural background conditions at the Idaho Washington state line. Idaho water quality standards also limit turbidity to 25 NTUs above background for protection of cold water biota beneficial use protection. The EPA has approved both the Washington State and Idaho State water quality standards as being protective for cold water biota beneficial use support. This approach was communicated to the Washington Department of Ecology (WDOE) through the USEPA staff assigned to interstate coordination and was considered by WDOE to meet the requirements of Washington State water quality standards (Letourneau, 1997)

Water Quality Studies

In 1979, Idaho DEQ identified the South Fork of the Palouse River (SFPR) and Paradise Creek as having severe pollution problems due to erosion on dryland farming ground (IDHW-DEQ 1981). During high flows the concentration of suspended sediment ranged 1,000-3,000 mg/l; fecal coliform numbers increased downstream and exceeded Idaho water quality standards for secondary contact recreation. In 1981 and 1986, the Latah Soil and Water Conservation District pursued implementation of best management practices (BMPs) in the Paradise Creek watershed through a State Agriculture Water Quality Program Planning Project (Latah SWCD, 1981, 1986).

In 1988, DEQ conducted a nonpoint source assessment on the water quality of rivers, lakes, and groundwater in the State of Idaho (IDHW-DEQ 1989). Paradise Creek was identified as highly impacted by the following pollution sources: non-irrigated crop production, pasture land treatment, land development, storm sewers, and surface urban runoff. The primary pollutants affecting water quality include nutrients, sedimentation, temperature, flow alteration, habitat alterations and pathogens.

Dr. Fred Rabe, *et. al* (1993) evaluated the habitat and macroinvertebrate communities at four stations along Paradise Creek within the Moscow city limits. Data was collected on nine habitat parameters and 5 biological characteristics. Additional reference sites were assessed on Schwartz Creek, Twin Creek and Idler's Rest Creek. Schwartz Creek served as the primary reference condition. Analysis of collected data included habitat assessment, qualitative description, macroinvertebrate total abundance, species richness, EPT Taxa richness, EPT abundance, Hilsenhoff Biotic Index, and percent dominant taxa. Habitat scores were found to improve going downstream from Mountain View Park. Biological integrity of the macroinvertebrate community was highest at the two stations along Paradise Creek upstream of Highway 95. Water quality, habitat, and biologic integrity were all significantly higher for the reference streams than for

Paradise Creek (Rabe, *et.al.*, 1993).

The U.S. Environmental Protection Agency (1993) completed a draft Paradise Creek Water Quality Assessment that recommended a TMDL be developed as part of the pollution control strategy. The strategy recommended the following steps: evaluate nutrient removal from the MWWTP, evaluate the need for and potential effectiveness of a Nutrient Management Plan, evaluate available controls via the Palouse Conservation District effort, evaluate the effectiveness of Storm water controls, evaluate the effectiveness of nutrient reductions on dissolved oxygen levels, and address bacterial contamination through programs controlling grazing, concentrated animal feeding operations, and urban runoff.

Limno-Tech, Inc. prepared a case study report entitled "Development of a Demonstration TMDL for Paradise Creek" (Limno-Tech, 1993). That TMDL consisted of four activities: defining water quality objectives, determining allowable loading and present nonpoint loads, defining necessary load reductions, and allocating loads. The analysis concluded that implementation of agricultural BMPs is necessary to achieve the suspended particulate objective and winter nutrient objectives. The report also concludes that reductions in the MWWTP nutrient loadings are necessary to achieve the summer nutrient water quality objectives.

The State of Washington, Department of Ecology has developed a TMDL for ammonia for the South Fork of the Palouse River (Pelletier 1993). Three Wastewater Treatment Plants (WWTPs) discharge water into the SFPR, including the MWWTP via Paradise Creek. The WWTPs have the potential to account for most of the river flow during low flow periods. Nonpoint sources of ammonia were found to be relatively dilute compared to point sources. Ammonia concentrations in excess of chronic criteria were observed in Paradise Creek near the state line in October 1991.

A Paradise Creek Watershed Characterization Study (Doke and Hashmi, 1994) was prepared for the Palouse Conservation District by graduate students at the State of Washington Water Research Center (SWWRC), Washington State University. An overview of the watershed examined the following topics: geology, hydrology, soil characteristics, climate, vegetation, wildlife, land use/zoning, population, and water quality problems. Water samples were collected monthly from nineteen sites on Paradise Creek and its tributaries between October 1992 and November 1993. Monitoring also took place following several storm events to measure peak loading of pollutants to Paradise Creek. Parameters that were investigated include: temperature, conductivity, pH, dissolved oxygen, alkalinity, suspended solids, ammonia, nitrite, nitrate, total phosphorus, stream flow, fecal coliform, and fecal strep. Agricultural runoff and discharges from the Moscow wastewater treatment plant were identified as the major pollutant sources. Traditional BMPs for construction, riparian, and agriculture were recommended to reduce sediment and nutrient loading to the creek.

Idaho DEQ conducted a beneficial use attainability assessment (Wertz, 1994) in October of 1993 to evaluate the appropriateness of the current designated beneficial uses. Water quality monitoring was conducted at four watershed locations. The physical and chemical parameters evaluated were: water temperature, pH, dissolved oxygen, conductivity, alkalinity, suspended solids, nitrogen, phosphorus, and flow. Biological parameters that were evaluated included: fish species, habitat quality, benthic macroinvertebrates, and bacteria. Results of the use attainability assessment indicated secondary contact recreation and agricultural water supply were appropriate designated beneficial uses. Cold water biota was found to be an existing use and salmonid spawning was determined to be attainable but nonexistent. The study concluded salmonid populations could be supported with improved water and habitat quality.

The State of Washington Water Research Center (Schnabel and Wilson, 1996) conducted a water quality monitoring study for Idaho DEQ from August 1994 to November 1995. The monitoring objective was to collect sufficient water quality data from seven sampling stations to provide information for development of a total maximum daily load for the Idaho portion of Paradise Creek. Pollutants of concern were: nutrients, bacteria, and sediment.

The Latah Soil and Water Conservation District with the USDA Natural Resource Conservation Service completed a Preliminary Investigation (PI) to assess water quality problems associated with Paradise Creek (USDA, 1995). The PI inventoried all known major point and nonpoint sources of pollution, summarized existing water quality monitoring results and aquatic habitat descriptions. Treatment alternatives developed during the preparation of the Palouse Conservation District's Paradise Creek Comprehensive Water Quality Management Plan were reviewed and rated. Implementation activities, both present and proposed, were listed with estimated costs (Palouse Conservation District, 1997).

Water Quality Problems

The 1996 303(d) list for the State of Idaho lists seven pollutants of concern. Four of these pollutants (nutrients, ammonia, temperature, and flow alteration) lead to eutrophic conditions. The remaining three (sediment, pathogens, and habitat modification) affect cold water biota and secondary recreation.

Excessive nutrients and high water temperature lead to algal growth and subsequent dissolved oxygen fluctuations. Temperature and dissolved oxygen within Paradise Creek typically do not meet water quality standards during the low flow period of the year. Excessive sediment impairs cold water biota and habitat. Ammonia is toxic to aquatic organisms and consumes oxygen during nitrification. Fecal coliform concentrations have been measured at seven times the maximum limits set by the Idaho Water Quality Standards for secondary contact recreation during low flow periods.

Dissolved oxygen (DO) depletion is a concern during the summer low flow months throughout the watershed. During this period, DO concentrations often drop well below Idaho and Washington standards. BOD loading from the MWWTP results in sub-standard oxygen levels throughout the year at the Idaho-Washington border. Beneficial uses such as cold water biota are impaired by low oxygen concentrations. Dissolved oxygen and water temperatures are both parameters of concern because they often fail to meet Washington State standards which are designed to support salmonids and healthy macroinvertebrate populations.

Suspended solids pose a significant seasonal threat in all but the forested stretches of the stream, often violating narrative water quality standards and adversely affecting many present and potential beneficial uses. The high suspended solids concentrations observed during peak runoff are of great concern because they reduce water clarity and impair fisheries and when deposited, sediment degrades fish habitat of Paradise Creek.

Ammonia concentrations greatly exceed proposed standards at the Idaho-Washington border due to discharges from the MWWTP. Ammonia levels at the border are sufficient to compromise many of the beneficial uses of a Washington Class A waterbody.

Beneficial Use Support

IDAPA 16.01.02.053 establishes a procedure to determine whether a water body fully supports designated and existing beneficial uses, relying heavily upon aquatic habitat and biological parameters, as outlined in the *Water Body Assessment Guidance*. IDAPA 16.01.02.054 outlines procedures for identifying water quality limited waters which require TMDL development, publishing lists of Water Quality Limited waterbodies, prioritizing waterbodies for TMDL development, and establishes management restrictions which apply to water quality limited waterbodies until TMDLs are developed.

The DEQ Beneficial Use Reconnaissance Project (BURP) was conducted on Paradise Creek in 1994, 1995 and 1996 (Wertz, 1997). The BURP survey collects data on fish, macroinvertebrates and habitat to determine a water body's beneficial uses and the support status of those uses for Idaho State Water Quality Standards (IDHW-DEQ, 1994,1995,1996). No trout were found, so salmonid spawning was not considered an existing use.

The BURP data was analyzed using the Water Body Assessment Guidance (WBAG) document (IDHW-DEQ, 1996). Paradise Creek is considered to be not in full support of beneficial uses because of the low macroinvertebrate biotic index (MBI) scores and numerous exceedances of water quality criteria. For each year the creek was surveyed, the MBI score indicated the macroinvertebrate population is impaired. BURP monitoring records have also shown that dissolved oxygen, ammonia and fecal coliform water quality standards were exceeded in the last five years. When major exceedances are documented, the corresponding beneficial use is considered to be not full support.

Available Monitoring Data

Data used in calculations for the Paradise Creek TMDL were obtained from those sources described below.

A USGS gaging station is located approximately 0.6 miles upstream of the Washington State line in Paradise Creek. Data is recorded hourly; daily averages and summary water year statistics are published in "Annual Water Records for Idaho" (USGS, 1997).

Discharge monitoring provided by the Moscow Wastewater Treatment (MWWTP) plant include outfall volume and effluent characteristics (MWWTP, 1997). The monitoring program began in 1979 and collects samples three times a week. Parameters measured include total suspended solids, pH, biological oxygen demand, fecal coliform, temperature, and dissolved oxygen. In addition, the MWWTP conducted an instream nutrient monitoring program from May 1992 to August 1995.

Inflow and outflow monitoring conducted by the University of Idaho Aquaculture Laboratory include: pH, dissolved oxygen, temperature, flow, turbidity, ammonia, total Kjeldahl nitrogen, total phosphorus, total suspended solids, fecal coliform, and when added, formalin. These quarterly and monthly water samples have been collected since 1995.

Monitoring data was collected for Paradise Creek during several of the investigations listed in the "Water Quality Studies" section at the beginning of this chapter. Systematic water quality monitoring was conducted during two State of Washington Water Research Center (SWWRC) studies of Paradise Creek. Upon examining the 1992-1993 SWWRC water quality data (Doke and Hashmi, 1994), several observations can be made which apply to the entire watershed.

The State of Washington Water Research Center (Schnabel and Wilson, 1996) conducted a water quality monitoring study for Idaho DEQ from August 1994 to November 1995. Samples sites correspond to those in the water quality assessment section of the Paradise Creek Watershed Characterization Study (Doke and Hashmi, 1994). Results of the water quality monitoring program support the findings of previous studies and indicate substantial impairment of water quality in Paradise Creek and provide the basis for pollutant loading estimates.

Data Gaps

The Idaho Beneficial Use Reconnaissance Project has provided annual monitoring of beneficial use support status on Paradise Creek. Monitoring of beneficial use support status will continue on an annual basis in addition to monitoring the goals and actions associated with the Paradise Creek TMDL.

A watershed monitoring program will be developed specifically to confirm and/or provide information to determine the validity of the assumptions made in the development of the Paradise Creek TMDL. Monitoring will be performed to determine the effectiveness of the TMDL and any associated actions implemented to meet TMDL targets.

Additional monitoring should further substantiate contributions of pollutants of concern for different portions of the Paradise Creek watershed. To a large extent, background levels of pollutant concentrations are based on approximations and less than optimal data sets. Background phosphorous concentrations and the phosphorous concentration threshold stimulating excessive aquatic plant growth needs to be confirmed.

Load capacity and allocations for the temperature targets were determined using an eight AM temperature collected within the top portion of the water column three times a week year round. Additional temperature monitoring during the implementation portion of this TMDL might determine how this morning temperature relates to the daily average and maximum temperature.

2.3 POLLUTANT SOURCE INVENTORY

Pollutants and Sources

The primary nonpoint sources in the Paradise Creek watershed at this time are non-irrigated croplands, grazing lands, land development and construction activities, City of Moscow's storm water system, and road and skid trail construction associated with forest land harvest activities (USDA, 1995). Agricultural related nonpoint source pollution is caused by tillage practices and livestock management. Silvicultural related nonpoint source pollution is caused by forest road and skid trail construction. Urban related nonpoint pollution is caused by construction activities, resident and business activities, roadways, and parking lots.

National Pollution Discharge Elimination System (NPDES) point sources permitted by the EPA include the Moscow Waste Water Treatment Plant (MWWTP) and the University of Idaho Aquaculture Laboratory.

NPDES Permitted Facilities

City of Moscow Waste Water Treatment Plant (ID-002149-1)
The MWWTP is adjacent to Paradise Creek on the south side of the Moscow-Pullman highway near the Idaho-Washington border. The plant consists of primary settling, two trickling filters, followed by a chlorination/dechlorination treatment step. Typical effluent flows are in the range of 2 to 2.5 million gallons per day. Current plant expansion involves the development of a filter press for sludge de-watering and the addition of sulfur dioxide dechlorination.

Water quality monitoring data indicates that the effluent from the MWWTP is a significant source of nitrogen in all forms, and phosphorus as orthophosphate (MWWTP, 1997). Schnabel and Wilson (1996) calculated the MWWTP outfall provided 90 percent of the total phosphorus loading to Paradise Creek, based on a monitoring study conducted by them from August 1994 to November 1995, but only 4 percent of the TSS.

During the low flow periods of the year, the effluent from the plant can comprise upwards of 90 percent of the total stream flow downstream of the treatment plant. During the months between June and September portions of the treated effluent are land applied through the University of Idaho's irrigation system. In 1997, the percentage of effluent land applied ranged from 12% in May to 33% in August (Haselhuhn, personal communication).

University of Idaho Aquaculture Research Facility (ID-002715-4)
The University of Idaho Aquaculture Research Facility is designed to study fisheries and aquaculture management. Waste water is discharged at times into Paradise Creek. Well water is pumped into the facility, circulates briefly, and is then discharged. Outflow rate from the facility fluctuates depending on the current research direction. The effluent from the facility is often discharged to the existing University of Idaho irrigation system rather than to Paradise Creek. The facility sometimes adds formaldehyde as a fungicide to a concentration of 2-5 ppm

(Hutchison, 1997). Formaldehyde has not been used at the site since July 1994. Future discharges of formaldehyde depends on the nature of the research conducted at the facility.

When formaldehyde is not in use, land application of the aquaculture effluent can occur through the University of Idaho's irrigation system. The wastewater is discharged to Paradise Creek when land application is not possible. The facility's discharge outfall is located a short distance downstream of the MWWTP effluent discharge pipe.

The current NPDES permit recognizes Paradise Creek flows are not large enough to support a mixing zone during much of the year. The following permit limits apply to the end of the discharge pipe: daily minimum DO levels must be at least 8.0 mg/l; daily maximum formaldehyde discharge must be no greater than 2.0 mg/l or 3.7 lbs/day; fecal coliform bacteria must be no greater than 200 colonies per ml on a weekly average or 100 colonies per ml on a monthly average; and the total residual chlorine must be below detectable limits. These permit limits comply with both Idaho and Washington water quality standards and are met at the end of the discharge pipe.

Other Potential Point Sources

Several other potential point sources of pollution have been identified in the Paradise Creek watershed (USDA, 1995).

Leaking Underground Storage Tanks:
IDEQ records show that there are 6 leaking underground petroleum storage tanks in the City of Moscow in some stage of remediation (Edwards,1997). The primary impact of these tanks are to the shallow perched groundwater system that underlies the Moscow basin and is a primary recharge source for the creek and its tributaries . However, samples collected down gradient from several of these sites have not shown detectable levels of petroleum contamination.

Hazardous Material Site:
A ten-acre tract of land bounded by Sweet Avenue, Railroad Street, and former Burlington Northern Railroad right-of-way has been remediated by the University of Idaho and Unocal Corporation. The University of Idaho has pursued remedial actions for petroleum contaminated soil at the site. Unocal Corporation has pursued remedial actions for pesticide, nitrate, and ammonia soil contamination at the site. Subsequent groundwater monitoring indicates that negligible residual pesticide, nitrate and ammonia groundwater contamination remains on the site. Contaminated ground water is not detectable in down-gradient monitoring wells or in Paradise Creek. Additional investigations are planned for the summer of 1997 (Grupp, 1997).

Nonpoint Source Pollution

Nonpoint pollution sources in the Paradise Creek watershed include agriculture, livestock, forestry, urban runoff, household hazardous waste, construction, septic system failure, mining, recreation and wildlife. The relative contribution of several of these sources individually to the overall degradation of Paradise Creek is unknown. Agriculture and urban runoff are the two major sources of nonpoint pollution in the watershed and are better characterized within this report than other sources.

Agriculture represents the largest land use in the watershed. Pollutants that come from agricultural practices include sediment, nutrients, organic materials, pesticides, and herbicides. The Palouse hills are very susceptible to erosion due to their topography, soil texture, and lack of vegetative cover during the period of maximum precipitation (November-March). Sediment sources evaluated which are affected by vegetative cover include agriculture, forest roads, county roads, unpaved urban roads, and construction activities (Appendix A).

Animal Waste Management

There are several agricultural operations and rural residences which raise pets and other farm animals including cows, horses, chickens, ducks, dogs and cats, etc. However, as of December 1997, there are no confined animal feeding operations included in the general coverage permit for Idaho under EPA's National Pollutant Discharge Elimination System (NPDES) Confined Animal Feeding Operation (CAFO) list within the Paradise Creek watershed (Cardwell, 1997). Although there are situations where urban and farm pets and animals have complete access to the creek and may contribute nutrients to the creek, the potential impacts from these situations are not considered to be of a magnitude which would require any to be assessed as a point source for a specific pollutant.

The University of Idaho pastures and boards farm animals near the creek but does not provide direct access to the creek. The number of animals included in the operation varies but is not large enough to require CAFO general permit coverage. A surface water drainage system exists which approaches the holding pens and transects the pasture area. The drainage has been enhanced to convey runoff from the area. Although animal waste materials may affect the quality of runoff, the conveyance is not designed or operated to transport, treat, or dispose of wastes. Dairy animal wastes are managed under the guidance of the University of Idaho's Department of Animal and Veterinary Science pursuant to the Idaho Animal Waste Management Guidelines for Confined Feeding Operations (DEQ, 1993). Effects on water quality from animals within the drainage have been addressed and incorporated into the TMDL as nonpoint source contributions.

Septic Drain Fields:

It is assumed that any housing units in the watershed outside of the city will use a septic system with drainfield. Other than an extensive site specific investigation, there is no accurate way to determine which drainfields are working properly or which are influencing water quality within Paradise Creek.

Urban Storm water Runoff:

One hundred and forty four pipes have been identified as directly discharging into Paradise Creek from within the City of Moscow (Thornbrough, 1993). Of these 125 pipes, 77 are street storm drains from 1,085 catch basins. Thirty four are from basements, backyards, and play fields and the remainder are from unknown sources. It is suspected that some may be old septic drain field outlets.

Mines:

There is no evidence to suggest that historical mining activities currently contribute to water quality problems in Paradise Creek. There is some gravel pit mining active today where basalt is exposed within the Washington portion of the watershed. Crushed basalt is used in Latah and Whitman counties as a road cover.

2.4 POLLUTION CONTROL EFFORTS

Paradise Creek was enrolled in the Idaho Adopt-A-Stream Program in 1990 (PCEI, 1990). The Palouse-Clearwater Environmental Institute manages the project and organizes activities such as trash removal, re-vegetation in the riparian zone, and the development of a pedestrian/bicycle path along the creek. A survey of pipes which discharge to or end in Paradise Creek has been completed by PCEI. Each pipe was photographed and its location recorded (Thornbrough, 1993).

The City of Moscow Waste Water Treatment Plant has recently installed a de-chlorination process to eliminate chlorine to the creek. A sludge handling system was installed two years ago. The plant has installed new head works to better remove solids.

The Paradise Creek Restoration Project initiated by PCEI (1994) and funded under section 319 of the Clean Water Act is a private/public cooperative effort to improve water quality in Paradise Creek through watershed restoration and nonpoint source pollution prevention projects. Phase One included restoration and re-vegetation of the floodplain at the Moscow School District Site. Phase Two (1995) included construction of a wetlands treatment system at the University of Idaho near the MWWTP. Phase Three (1996) includes the restoration of the floodplain area and construction of grassy swales and pocket wetlands to treat Storm water runoff at the Sweet Avenue Site at the University of Idaho. The University of Idaho received the grant and subcontracted the work to PCEI. Phase Four (1997) includes re-vegetating the urbanized riparian floodplain and associated wetlands along Paradise Creek from Main Stream to Mountain View Park. Stream banks will be stabilized with various bioengineering techniques. Finally, PCEI has submitted a Phase Five 319 proposal to IDEQ and EPA to restore the channel and floodplain and re-vegetate one mile of Paradise Creek upstream of the City of Moscow.

The Palouse Conservation District has produced a comprehensive watershed management plan for Paradise Creek. In the process of preparing the plan, the District identified and evaluated various nonpoint source pollution control strategies to determine the most feasible alternative. Present and planned activities are expected to achieve water quality improvements in a reasonable time frame. This document is expected to serve as the basis for satisfying many of the TMDL process requirements for implementation planning.

Federal Requirements for Water Quality Limited Waters

The Federal Clean Water Act (CWA) requires restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters (Public Law 92-500 Federal Water Pollution Control Act Amendments of 1972). Each state is required to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the water whenever attainable.

Section §303(d) of CWA establishes requirements for states to identify and prioritize waterbodies which are water quality limited (i.e.. waterbodies which do not meet water quality standards).

States must publish a priority list of impaired waters every two years. For waters identified on this list, states must develop Total Maximum Daily Loads (TMDLs) set at a level to achieve water quality standards. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety and natural background conditions. In essence, TMDLs are water quality management plans which allocate responsibility for pollution reduction with a goal of achieving water quality standards within a specified period of time.

Reasonable Assurance Of Nonpoint Source Reductions

The US Environmental Protection Agency (EPA) requires that TMDLs that have a combination of point sources and nonpoint sources, and have waste load allocations that are dependent on nonpoint source controls, provide reasonable assurance that the nonpoint source controls will be implemented and effective in achieving the load allocation (EPA 1991). If reasonable assurance that nonpoint source reductions will be achieved is not provided, the entire pollutant load will be assigned to point sources. In the case of Paradise Creek, flow volumes are not large enough to support a mixing zone during most of the year. The lack of a mixing zone requires all waste load allocations be based on the discharge flow and are applied to the end of the point source discharge pipe. Waste load allocations are not dependent on nonpoint source reductions to meet instream water quality standards because water quality standards will be met for the discharge prior to mixing with Paradise Creek. Because this TMDL does not have waste load allocations that are dependent on nonpoint source controls, reasonable assurance is not applicable.

Nonpoint source reductions listed in the Paradise Creek TMDL will be achieved through the combination of authorities the state possesses within the Idaho Nonpoint Source Management Program and the commitments the community has made previously in the existing Paradise Creek Watershed Water Quality Management Plan.

Section 319 of the Federal Clean Water Act requires each state to submit to EPA a management plan for controlling pollution from nonpoint sources to waters of the state. The plan must: identify programs to achieve implementation of the best management practices (BMPs); a schedule containing annual milestones for utilization of the program implementation methods, and for implementation of best management practices; certification by the attorney general of the state that adequate authorities exist to implement the plan; and a listing of available funding sources for these programs. The current Idaho Nonpoint Source Management Program has been approved by EPA as meeting the intent of section 319 of the Clean Water Act.

As described in the Idaho Nonpoint Source Management Plan, the Idaho Water Quality Standards require that if water quality monitoring indicates water quality standards are not met due to nonpoint source impacts, even with the use of current best management practices, the practices will be evaluated and modified as necessary by the appropriate agencies in accordance with the provisions of the Administrative Procedure Act. If necessary, injunctive or other judicial relief may be initiated against the operator of a nonpoint source activity in accordance with the Director's authorities provided in Section 39-108, Idaho Code (IDAPA 16.01.02.350).

The Idaho Water Quality Standards list designated agencies responsible for reviewing and revising nonpoint source BMPs based on water quality monitoring data as is generated through the state's water quality monitoring program. Designated agencies are; the Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; the Soil Conservation Commission for grazing and agricultural activities; the Department of Transportation for public road construction; the Department of Agriculture for aquaculture; and the Division of Environmental Quality for all other activities (IDAPA 16.01.02.003).

Existing authorities and programs for assuring implementation of BMPs to control nonpoint sources of pollution in Idaho include:

State Agricultural Water Quality Program	Nonpoint Source 319 Grant Program
Wetlands Reserve Program	Conservation Reserve Program
Environmental Quality Improvement Program	Resource Conservation and Development
Idaho Forest Practices Act	Agricultural Pollution Abatement Plan
Water Quality Certification For Dredge and Fill	Stream Channel Protection Act

The Idaho Water Quality Standards directs appointed watershed advisory groups to recommend specific actions needed to control point and nonpoint sources affecting water quality limited waterbodies. Upon approval of this TMDL by EPA Region 10, the existing Paradise Creek Watershed Advisory Group, with the assistance of appropriate state and federal agencies, will begin formulating specific pollution control actions for achieving the water quality targets listed in the Paradise Creek Total Maximum Daily Load. An implementation plan is to be completed within eighteen months of finalization and approval of the TMDL by EPA.

The Paradise Creek Watershed Water Quality Management Plan pre-dates the Paradise Creek TMDL and was conceived and developed as the most appropriate plan for community implemented point and nonpoint source water quality pollution controls (Palouse SCD 1997). The Plan lists activities which will be implemented by the community to enhance the water quality of Paradise Creek. The Plan includes costs, funding sources and a schedule for implementation of each activity. Activities include but are not limited to; riparian tree plantings, agricultural best management practices, bioengineering structures, wetland restoration and urban Storm water system upgrades, development of a tax relief policy for riparian areas, development of a erosion control ordinance and education and information programs to increase community awareness of the Creek's water quality conditions and the activities to be undertaken to restore the creek's water quality.

Appendix B of the Paradise Creek Watershed Water Quality Management Plan includes letters of commitment for various activities from a number of participants. Participants include but are not limited to: Latah County Commissioners, Latah Soil and Water Conservation District, City of Moscow, Idaho Division of Environmental Quality and the Palouse - Clearwater Environmental Institute. These letters of commitment precede the development of the TMDL as does the Watershed Plan and many of the activities listed in the plan have been completed or are underway.

3.0 PARADISE CREEK LOADING ANALYSES AND ALLOCATIONS

Paradise Creek is listed on Idaho's 1996 §303(d) list for seven pollutants: sediment, nutrients, thermal modification, flow alteration, habitat modification, pathogens, and ammonia. Pollutant targets, pollutant loads, pollutant allocations and pollutant load capacity are presented for sediment, total phosphorus, temperature, bacteria and ammonia in this section.

Pollutant targets are based on numeric water quality standards where they exist, or interpretation of narrative water quality standards in the case of sediment and nutrients. Current pollutant loads are presented as mass per unit time. Pollutant load allocations are presented as a function of available flow and allowable pollutant concentration based on the pollutant targets. Load capacity is divided among load allocations, waste load allocations and a margin of safety. When water quality monitoring data show that water quality standards have been met and beneficial uses are fully supported, the TMDL is successful. If this were to occur before the load reductions were reached, the pollutant target, load capacity and allocations would need to be revised.

Compliance for the listed load allocations will apply to Paradise Creek at the Idaho-Washington border as a function of available flow. The Washington State and Idaho State border is appropriate for the Paradise Creek TMDL compliance point since the TMDL is based on meeting the receiving water state's water quality standards and the flow and water quality data used to calculate loads were obtained from the Moscow Wastewater Treatment Plant and the USGS flow station located near the border.

The EPA Region 10 does not currently require habitat modification and flow alteration to be addressed as TMDL pollutants since they do not lend themselves to meeting the minimum requirements of a pollutant load (mass/time) as defined by EPA guidance on TMDL development. Because of these practical limitations, habitat modification and flow alteration will not be assigned a load allocation in the Paradise Creek. Flow and habitat modifications will be addressed through activities implemented for listed pollutants which are addressed in this TMDL.

3.1 SEDIMENT

Target

Turbidity levels in excess of 25 Nephelometric Turbidity Units (NTU) over prolonged periods have been found to increase mortality of aquatic organisms (IDEQ, 1989). The Idaho and Washington State water quality standards recognize this and provide numeric limitations for turbidity concentrations for full support of cold water beneficial uses.

Sediments other than those causing turbidity may impact cold water biota. It is assumed that a reduction in sediment loads causing excess turbidity will ultimately reduce the total sediment load delivered to the creek. The reduction of total sediment delivered to the creek will reduce impacts to beneficial uses.

A numerical sediment target was arrived at by relating Idaho's turbidity standard (IDAPA 16.01.02.250.02.c.iv) to total suspended solids (TSS). Studies conducted by the Washington Department of Ecology (Joy, 1987) indicate that the TSS/turbidity relation in Paradise Creek is about 2:1 (Figure 8). Applying this 2:1 relation between NTU and TSS leads to a TSS target of 100 mg/l maximum <u>above natural background</u>, or, not to exceed 50 mg/l <u>above natural background</u> over a 10 day period. Research has found that suspended sediment levels in excess of 50 mg/l for prolonged periods can have severe ill effects on a variety of aquatic organisms (Newcombe and Jensen, 1996).

Loads

<u>Nonpoint Source Load</u>
A sediment load for TSS in Paradise Creek was determined using USGS flow data and thrice per week measurement of TSS concentrations collected by the City of Moscow Waste Water Treatment Plant. A sediment/flow rating curve based on a subset of the TSS samples and instantaneous flows from the USGS allowed an average annual load of TSS to be estimated. These data show the current amount of TSS present within Paradise Creek upstream of the wastewater treatment plant to be 1040 tons/yr on average.

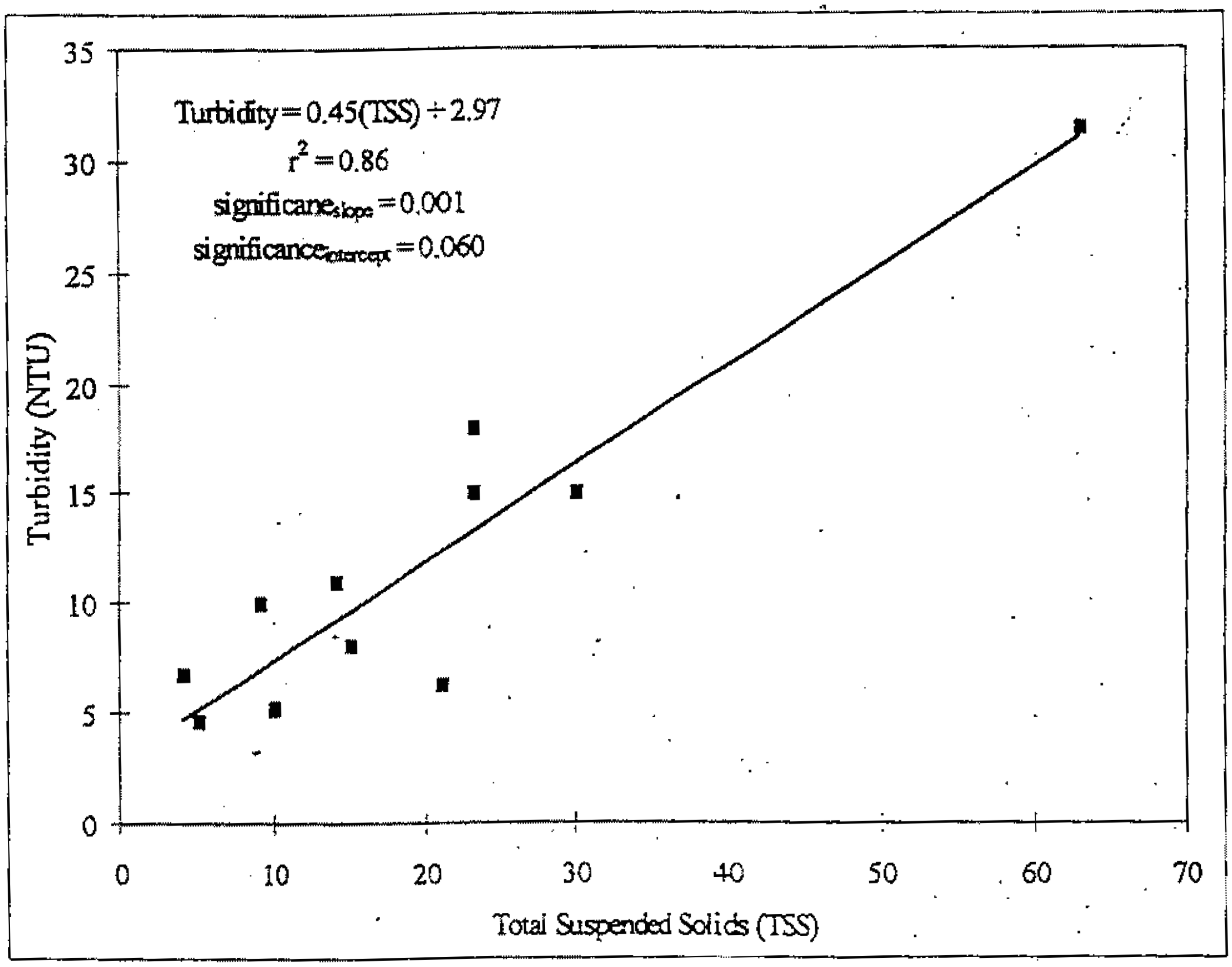
Proportioning of the current TSS load among potential non-point contributions (the various land uses) was accomplished using the Water Erosion Prediction Project model (WEPP) (ARS, 1997). The WEPP model estimates the portion of the TSS load found in Paradise Creek originating from agricultural areas is 81%, 7% from forested areas, 5% from urban areas, and 8% from county roads. These estimates are based on the available sediment loads within each of these land uses and may incorporate up to a 20% error due to uncertainty in the actual sediment delivery ratio and land use change. These results are discussed in more detail in Appendix A.

<u>Moscow Wastewater Treatment Plant Load</u>
Total Suspended Solids grab samples and flow rates were collected at the outflow pipe of the MWWTP three times a week from September 1993 through August 1996 (MWWTP, 1997).

During this period, the measured TSS loading to Paradise Creek from the MWWTP averaged 239 pounds per day (lbs/day) or 44 tons annually. This results in an average TSS concentration of 11 mg/l for an average effluent discharge of 2.5 million gallons per day (MGD). Adjusting for the permitted effluent discharge limit of 4.0 MGD at 15 mg/l concentration, the daily load could reach 500 pounds per day (lbs/day). If discharge continued at this rate for an entire year the load would be 91 tons per year (tons/yr).

Figure 8.

Total Suspended Solids vs. Turbidity Washington State Border (Joy, 1987)



Aquaculture Facility

Self-monitoring was conducted by the University of Idaho Aquaculture Research Facility as required by their NPDES permit. These data indicate that concentrations of TSS leaving the facility are always below 10 mg/l. Actual concentrations lower than 10 mg/l were not measured. Assuming a constant discharge of 140 gallons per minute (gpm) and a 10 mg/l average concentration, an upper estimate of the current TSS load is 3 tons/yr. This is 60 percent of the facility's current load allocation of 5 tons/yr.

Sediment Allocations

Table 2 lists the calculated TSS load allocations. Nonpoint TSS allowable load calculations were based on natural background concentrations and target concentrations. As mentioned, current water quality standards for turbidity are based on an increase over natural background levels. The differences in annual erosion rates from plot scale modeling for the Paradise Creek watershed indicated that the natural background erosion rate is about 18 percent of the current erosion rate (Appendix A).

A load capacity of 356 tons/yr of total suspended sediment was derived by applying the TSS target as a floating increment above estimated background concentrations. Background concentrations were back calculated from instantaneous loads reduced to 18% of their observed values (see Appendix A, Table A5). Using this method accounts for natural conditions in which TSS concentrations increase as flows increase (i.e. background TSS concentrations are flow dependent).

A point source TSS load allocation was determined for the MWWTP. The current allocated load is based on the proposed permit discharge limit of 4.0 MGD and a proposed TSS target of 15 mg/l, or 91 tons/yr. This load allocation and the final load capacity for Paradise Creek are based on target concentrations and permitted effluent discharge. Because of the concentration requirements, when the discharge rate decreases, the allocated load decreases as well. Because this allocation is based on an end of pipe concentration of 15 mg/l, which is less than the target instream concentration, no reduction in current TSS is required form this source.

Currently, there are no limits of TSS specified within the Aquaculture facility NPDES permit. However, it is recommended that a concentration of 15 mg/l not be exceeded at the end of the facility's discharge pipe. No flow limits have been specified either (NPDES Permit ID-002715-4). Therefore, the current load allocation is based on the maximum rate allowed by the facility design, or 140 gpm. The target concentrations for this amount of flow translates into an waste load allocation of 5 tons/yr. Monitoring results show that TSS concentrations have not exceeded 10 mg/l, indicating that no reductions in TSS by the facility is required.

Subtracting the wasteload allocations from the loading capacity gives 260 tons/yr as the average annual TSS load allowable from nonpoint source activities, including the margin of safety (MOS). Achieving the non-point source allocation will require about a 75% reduction in current load.

Table 2. Total Suspended Solids Allocation

Source of Load	Amount (Tons/yr)
MWWTP Wasteload Allocation[1]	91
SITE Wasteload Allocation[2]	.5
Nonpoint Load Allocation (LA)[3]	156
Margin of Safety (MOS)[4]	104
TSS Load Capacity	356

[1] Based on maximum concentration of 15 mg/l for the permitted 4.0 MGD.
[2] Based on maximum concentration of 15 mg/l for an estimated 140 gpm.
[3] Based on background levels and allowed concentrations above background.
[4] Reflects 10 percent of current nonpoint load.

Margin of Safety

The margin of safety for point source sediment allocations are based on the conservative use of 15 mg/l of TSS. This is below the instream water quality target and will not impair cold water biota (Newcombe and Jensen, 1996). Therefore no explicit margin of safety has been included in the load allocations for point sources. The margin of safety for nonpoint source sediment allocations is 10% of the current load, or 29% of the load capacity. The margin of safety was based on current load to compensate for uncertainties inherent in the background sediment calculations.

3.2 TEMPERATURE

Target

Low stream temperatures need to be maintained during all seasons of the year in order to support aquatic biota and to limit algae growth. The Paradise Creek in-stream temperature target is 18 °C maximum instantaneous. The target is based on current State of Washington Water Quality Standards for Class A waterbodies (WAC 173-201A-030) and is applied at the state line due to interstate requirements, as discussed earlier. Load capacity is presented in terms of temperature (measurable indication of heat load).

Loads

Nonpoint Source Load

The current stream temperatures due to point and non-point activities in Paradise Creek were determined through surface stream temperature measurements by the MWWTP. Current stream temperatures stemming from nonpoint activities were estimated using the most comprehensive temperature data set available. This data was collected upstream of the MWWTP consistently at 8:00 AM, within the top portion of the water column.

These data show numerous exceedences of the established maximum temperature target (Appendix B). The critical period of the year for stream temperature exceedences is during times of low flow and high air temperatures, typically late summer. Three different methods were used to determine the current stream temperature during these times, all three utilized the 8:00 AM stream temperatures collected by the MWWTP. The three methods were an the upper 95th percentile for summer data (June - September), the most frequent annual maximum, and the 2 year return period peak temperature. All three of these methods converged on a stream temperature of 21°C. This temperature, 21 °C, characterizes peaks in the current 8:00 AM stream temperature loading regime upstream of the MWWTP. A 2°C margin of safety was added to this 8:00 AM temperature to approximate peaks in the daily maximum temperature (Appendix B).

Moscow Wastewater Treatment Plant Load

Waste water from the MWWTP is discharged into Paradise Creek year round. The summertime outflow temperature from the MWWTP was determined by taking the average of temperatures recorded at 8:00 AM, three times a week, during the months of June - September for the period of record. Effluent temperatures were found to average 19°C during the summer months.

Aquaculture Facility

Waste water from the University of Idaho Aquaculture Research Facility is also discharged into Paradise Creek. The inflow temperature to the facility is generally low (i.e. 13.1°C max) and the change in temperature due to the brief circulation through the ponds is +/- 0.5°C. This temperature is well below the temperature targets for Paradise Creek.

Temperature Allocations

To meet the water quality target stream temperature within Paradise Creek must not exceed 18°C at any time. Point source temperature loading to a stream may increase the stream temperature near the outfall, then decrease as energy is dissipated to cooler ambient air or by mixing with cooler stream temperatures. However, such a decrease in temperature of effluent discharged to the stream can only occur when the ambient air or stream temperature is less than the effluent temperature. Therefore, in order to meet the target established at the state line, the temperature of water discharged to the stream must be at or below 18°C unless the ambient air temperature or the stream temperature is less than 18°C.

Paradise Creek temperatures were assessed and allocations were developed for nonpoint and point sources by using a steady state, conservation of mass, and conservation of energy approach. The mathematical relationships used in this approach are presented in Appendix B. In this method, a characteristic seep inflow temperature is compared with ambient and target temperatures.

The proportional differences between the seep and target temperature and the seep and ambient temperature provide a percent difference in energy content and which is related to temperature target exceedances. An estimated 42% percent reduction in energy input is required by non-point activities in order to meet the temperature target (Appendix B). The intermittent nature of Paradise Creek at low flows requires this reduction take place in perennial portions of the stream.

The temperature for the stream segment downstream of the MWWTP is primarily a function of the MWWTP outflow volume and temperature, and the flow and temperature of Paradise Creek. The allowable rate of discharge for the MWWTP for a variety of Paradise Creek flows and temperatures are presented in Appendix B. When the stream temperature in Paradise Creek is at 18°C or above, the assimilative capacity of the creek is reached and the effluent temperature must be no greater than 18°C at the end of the discharge pipe.

The allocation of 18°C applies to the University of Idaho Aquaculture Research Facility as well. The facility's outflow was evaluated for its beneficial influence on the stream temperature of Paradise Creek. Two factors were found to limit outflow benefits: the outflow is delivered to Paradise Creek at a fairly low rate (max = 0.6 cfs), and land application of the outflow occurs during the low flow season. Because of these factors little or no cooling currently occurs within Paradise Creek as a result of the facility's outflow.

Margin of Safety

The uncertain relationship between the 8:00 AM temperature and the maximum temperature was taken into account by adding 2°C to the current stream temperature based on 8:00 AM measurements. By adjusting the current temperature condition upward greater reductions in thermal input are called for, providing assurance the target will be meet even if the difference between morning and maximum temperature is an underestimate.

A 10% MOS was also applied to the MWWTP effluent temperature for the current loading assessment. The amount of outflow from the MWWTP, however, was calculated based on conservative assumptions relating to conditions within Paradise Creek and do not require an additional MOS.

3.3 NUTRIENTS

Background

Nuisance algae growth and its effects on dissolved oxygen is complex and difficult to model. The rate of algae growth is limited by the availability of light, temperature and nutrients. If all constituents are available in excessive quantities, dense mats of algae will grow. Flow effects algae growth in a more indirect manner; low flows cause decreases in stream depth, velocity and reductions in water column volume vs. surface area. These changes may increase reaction rates, temperatures, and light available to aquatic vegetation; algal growth may be further stimulated and result in greater impacts on dissolved oxygen levels.

At present, it is not clear whether nitrogen or phosphorus is a limiting nutrient because concentrations of both elements in Paradise Creek are well above the accepted saturation levels; thus the use of N:P ratios to determine which nutrient is limiting is irrelevant. Because phosphorus is generally considered to be easier and more cost-effective to control, it will be addressed in this phase of the TMDL. If phosphorus controls provide inadequate improvements in water quality, nitrogen species other than ammonia-N may need to be examined in a future phase of the TMDL.

A United States Geological Survey (USGS) study of nutrients and algae during low stream flows concluded that benthic algae concentrations were higher between the Moscow WWTP and Pullman WWTP than anywhere else in the Palouse River system. There was not a significant correlation observed between growth of benthic algae and inorganic nitrogen or orthophosphate for the South Fork system (which includes Paradise Creek) because nutrient loading exceeded the nutrient requirements of the aquatic plants (Greene, K.E., Munn, M.M, and Ebbert, J.C., 1996). A load analysis for total phosphorus (TP) is described below; ammonia-N loading is described in a separate section.

Phosphorus is often the primary limiting nutrient in aquatic systems and is present in a number of organic and inorganic forms. Typically, greater than 90% of the TP present in freshwater occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel, 1983). The small remaining fraction is inorganic, largely orthophosphate (PO_4^{-3}), and in soluble forms that are rapidly assimilated by plants. As a result, this form of phosphorus tends to be rare in unenriched aquatic systems. Paradise Creek clearly has excessive amounts of TP and orthophosphate.

The State of Washington Water Research Center compared TP to orthophosphate and determined that during the 1994 to 1995 monitoring season, orthophosphate represented from 12% to 92% of the TP (Schnabel and Wilson, 1996). This suggests that phosphorus reaches concentrations exceeding the ability of plants to use it. In addition, water column concentrations of total phosphorus always exceed values considered indicative of eutrophication in fresh waters (Wetzel, 1983). The Moscow WWTP contributes approximately 85% of the TP load to Paradise Creek; data indicates 50%-90% of the total is orthophosphate.

According to Greene, Munn and Ebbert (1996), chlorophyll *a* in the South Fork Palouse system which includes Paradise Creek was not significantly correlated with any of the parameters measured in their study; this indicated that nutrient loading in this part of the Palouse River Basin exceeded the nutrient requirements of aquatic plants. Neither phosphorus nor nitrogen were limiting due to high concentrations of both. The authors further state "most of the inorganic nitrogen contributed by treatment plants was removed from the South Fork system before the confluence of the South Fork Palouse River with the Palouse River; however, orthophosphate concentrations remained high until much farther downstream". Inorganic nitrogen appears to be used up rapidly by a combination of denitrification and uptake by macrophytes. Both nitrogen and phosphorus are present in excessive amounts; the Moscow Wastewater Treatment Plant is identified in this report as well as several other reports as the primary source of nutrients to Paradise Creek. Natural processes are reported to remove approximately 93% (Greene, Munn and Ebert, 1996) of total nitrogen contributed by the Moscow and Pullman WWTPs within the South Fork of Palouse system but only 65% of the total phosphorus.

According to Krenkel and Novotny (1980), the removal of phosphorus is relatively less complex and less expensive than nitrogen removal processes for wastewater plant effluents. Because current evidence indicates that: 1) neither nitrogen nor phosphorus is a limiting factor at present due to excessive concentrations of both pollutants in the Paradise Creek-South Fork Palouse system, 2) natural removal of nitrogen occurs instream at a much higher rate than phosphorus removal, and 3) phosphorus removal from effluent is less complex and costly than nitrogen removal, it is logical to reduce phosphorus loading from the Moscow WWTP as an initial step to control nuisance algae growth.

The Idaho general surface water quality criteria states that "Surface waters must be free of excess nutrients that cause visible slime growth, or nuisance aquatic growth, which impairs beneficial uses." It is assumed that beneficial uses are impaired due to nutrients only when such growths are present and active. Nutrient loads would be a concern at other times of year only if significant quantities of nutrients were stored in bottom sediments during the dormant season and later became available during the growing season. This usually occurs in cases where there is a large concentration gradient between nutrients in the bottom mud (higher) and overlying water (lower) and is an order of magnitude more likely under anaerobic conditions (Krenkel and Novotny, 1980). There is no evidence this situation exists in Paradise Creek.

Although, at present, there is no data to prove it, a logical assumption is made that nutrients are not a year round problem in Paradise Creek. Based on the very fine grained nature of the sediment load (see geology section) and hydrology of Paradise Creek, it is reasonable to assume that most of bottom sediments are flushed during winter/spring high flows prior to the subsequent growing season and renewed accumulation of sediment. Therefore, it is assumed that there is an annual exchange of sediment and associated phosphorus; but no long term storage occurs. Even if this were not the case, there is no evidence that high concentration gradients or anaerobic conditions exist in Paradise Creek which could result in recycling of nutrients from sediment to overlying water. Further support for no net storage of sediment or attached phosphorus is provided by the lack of observed aggradation of the Paradise Creek channel.

Total Phsophorus Target

Natural background is the target proposed by EPA Region 10 for total phosphorus in Paradise Creek. Based on data collected by the Washington Water Research Center (Schnabel and Wilson, 1996) at the Idler's Rest Nature Conservancy monitoring site, natural background total phosphorus levels average approximately 0.136 mg/l. Observations at this upper watershed site indicate that even at these relatively elevated phosphorus levels, nuisance algae problems do not exist. This is thought to be due to the presence of good canopy cover and lower stream temperatures at this site. Dissolved oxygen concentrations are always greater than Idaho and Washington standards when flow is measurable at the Idler's Rest site. Using Idler's Rest Nature Conservancy site as an example, it is expected that algal growth may be minimized and desired dissolved oxygen levels obtained in the remainder of Paradise Creek through a combination of increased shading, reduction in temperature and decreased phosphorus loading to concentrations that will not support nuisance algal growth (Kimball, 1997).

Additional data will be collected during the implementation of this TMDL to more accurately characterize background phosphorus levels and to characterize the TP level which meets Idaho's narrative criteria. For the purposes of this TMDL, 0.136 mg/l will be considered natural background for total phosphorus in Paradise Creek. This interim target is subject to change as more data is made available. The target will only apply during normal growing season months (May -Oct) because the target is designed to address nuisance algal growth which is limited during the remainder of the year by other factors such as temperature, light, and water velocity.

A review of existing literature and documents prepared over the past 25 years by agencies in Washington and Idaho on phosphorus in the Spokane River/Long Lake system resulted in a recommendation of May 15 to October 15 as the initial period for limiting discharge of phosphorus to Paradise Creek from the Moscow Wastewater Treatment Plant (MacInnis, 1997). By applying a minimum productivity value (0.3 g C m^{-2} day^{-1}) to the 1985 algae productivity in Long Lake (fig.10, Soltero et.al, 1986) the algae growing season was defined as May 15 through October 15. As many differences as similarities can be identified between the Spokane/Long Lake system and the Idaho portion of Paradise Creek, so further study to determine site specific algal characteristics should be performed and corresponding adjustments to the growing season-discharge period implemented as more site specific information becomes available.

Loads

Moscow Wastewater Treatment Plant Load

Data was available from the Moscow Wastewater Treatment Plant (MWWTP) showing results of daily sampling for total phosphorus at the MWWTP outfall. Based on three years of recent data (9/1/93 to 8/31/96), total phosphorus values at the outfall during the May 15 to October 15 growing season are:

Daily Average TP Concentration	7.16 mg/l
1993-96 Daily Average Load	118 lbs = 21.5 tons/year

Daily Phosphorus Loading Capacity, based on 0.136 mg/l TP target	2.2 lbs

The above figures are based on 1.98 MGD average discharge for the time period examined; actual loads and loading capacity will change based on daily discharge variations.

Using the same daily average TP concentration and recalculating at the permit discharge limit (4.0 MGD), these loads become:

Potential Daily Average Load	236 lbs = 43.1 tons/year
Daily Phosphorus Loading Capacity @ 4.0 MGD	4.5 lbs

The Moscow WWTP contributes approximately 85% of the TP load above background to Paradise Creek annually and 98% of the TP load during the growing season. During the May to October growing season, discharge from the MWWTP exceeds 25% of the total flow in Paradise Creek over 96% of the time, rarely meeting Idaho mixing zone requirements. A reduction of approximately 98% in growing season load will be necessary to meet the proposed interim total phosphorus target of 0.136 mg/l at the discharge outlet.

Aquaculture Facility

Self-monitoring of the facility's discharge shows a maximum concentration of 0.13 mg/l TP; this is just below the interim target TP concentration. Maximum current load would be 0.2 lb/day TP at this concentration and the reported design flow rate (140 gpm), slightly less than the loading capacity of the effluent. Discharge from this facility does not normally occur during the growing season; the TP load to Paradise Creek during the critical time period is zero.

Nonpoint Source Loading to Paradise Creek

Instream phosphorus and flow data collected at a point in Paradise Creek above the plant outfall was examined to estimate total phosphorus nonpoint source loading above the MWWTP. This data was provided by the MWWTP (1997). The data set consists of 73 samples collected between 6/9/92 and 7/11/95. Results (May 15 to October 15) show:

Daily Average TP Concentration	0.40 mg/l
Daily Average Load	2.2 lbs = 0.4 tons/year
Daily Loading Capacity	0.9 lbs

These figures are based on 0.8 MGD average flow at the above MWWTP monitoring site during the growing season for the time period examined; actual loads and loading capacity will change based on daily flow variations. A reduction of approximately 1.3 lbs/day or 59% reduction in load will be necessary to meet the proposed total phosphorus target in Paradise Creek above the MWWTP outfall. Because most nonpoint phosphorus loading is directly related to sediment loading, any reductions in sediment loading are expected to produce a similar reduction in phosphorus loads. No additional efforts to specifically address nonpoint TP are expected to be necessary since required sediment load reductions are greater than TP reductions.

Urban Runoff

Urban total phosphorus loading calculated using the EPA "simple method" is 1758 lb/yr or approximately 24% of the total annual nonpoint source loading for the Idaho side of the Paradise Creek Watershed (see Appendix C). The bulk of the remainder of the nonpoint source phosphorus loading is assumed to be due to agricultural and forest activities linked directly to sediment loading from these sources.

Total Phosphorus Allocations

Total phosphorus load capacity during the growing season is 5.6 lbs/day on average. This is allocated as presented in Table 3. Combined wasteload allocations are 4.7 lbs/day based on proposed discharge limits. The MWWTP allocation is 4.5 lbs/day and the aquaculture facility allocation is 0.2 lbs/day. The MWWTP phosphorus allocation is based on a maximum 4.0 MGD discharge volume, the actual allowable load is discharge volume dependent and a permit will have to be written accordingly (e.g. concentration limit as well as maximum mass per day). The TP nonpoint source load allocation is also variable depending on flow, but averages 0.9 lbs/day based on the data sets examined.

Table 3. Total Phosphorus Allocation

Source of Load	Amount (lbs/day)
MWWTP Wasteload Allocation[1]	4.5
SITE Wasteload Allocation[2]	0.2
Nonpoint Load Allocation (LA)[3]	0.9
Margin of Safety (MOS)[4]	15%
Total P Load Capacity[5]	5.6

[1] Based on concentration of 0.136 mg/l for the permitted 4.0 MGD.
[2] Based on maximum concentration of 0.136 mg/l for an estimated 140 gpm.
[3] Based on concentration of 0.136 mg/l and mean growing season streamflow of 0.8 MGD (1.2 cfs).
[4] Margin of safety is implicit in the load capacity of 5.6 rather than 6.6.
[5] This is an average growing season load capacity, load capacity on any given day will vary with flow.

Margin of Safety

The more recent and conservative of two data sets was used to set background TP levels; assuming Idler's Rest Conservancy site data most closely reflects background conditions. The earlier data set (1993) indicated that background TP levels may average 0.21 mg/l; combined data gives 0.161 average TP. The 0.136 mg/l TP target (1994-1995 avg. conc.) is 15% more conservative than the combined average.

3.4 PATHOGENS

Target

Paradise Creek has pathogens listed as a pollutant of concern on the most recent 303(d) list; the presence of pathogenic bacteria in a waterbody may limit its beneficial uses and present human health hazards. Fecal coliform is a non-pathogenic indicator species whose presence suggests the likelihood that pathogenic bacteria are present. Fecal coliform is the type of bacteria that is addressed in Idaho and Washington state water quality standards. There are two major sources of fecal coliform to Paradise Creek, the Moscow Wastewater Treatment Plant and runoff from the city of Moscow and University of Idaho. Other discrete sources likely occur within the watershed and need to be characterized during the phased TMDL process.

The Washington State Class A water quality standards state that fecal coliform organisms shall not exceed a geometric mean value of 100 cfu/100 ml. This standard is more restrictive than the Idaho standard of 200 cfu/100 ml and will be the instream target for Paradise Creek at the Washington state line; it is also the proposed discharge limit for the Moscow Wastewater Treatment Plant and the University of Idaho Aquaculture facility. Because the MWWTP does not usually meet mixing zone requirements relative to flow and no loading capacity for pathogens is available instream until nonpoint source reductions are realized, it is recommended the MWWTP meet water quality standards at the end of the discharge pipe. Discharge limits are also proposed for the aquaculture facility.

Wasteload allocation for the MWWTP is based on the WA state standard and the volume of the recommended permitted discharge (4.0 MGD). Aquaculture facility allocation is based on 140 gpm design flow. The load capacity for nonpoint sources is based upon instream flow recorded just above the MWWTP. Based on three years (9/93 to 9/96) of recent data (MWWTP, 1997), fecal coliform concentrations average 326 cfu/100ml in Paradise Creek above the MWWTP outfall and 44 cfu/100ml at outfall for the entire time period.

Loads

<u>Moscow Wastewater Treatment Plant Load</u>
Discharge monitoring records (MWWTP, 1997) were available showing results of sampling for fecal coliform at the MWWTP outfall and both above and below the MWWTP in Paradise Creek. Samples were generally collected 2 to 3 times per week from these sites. Fecal coliform concentrations in Paradise Creek above the MWWTP are almost always higher than in the effluent discharge; no loading capacity for dilution of bacteria concentrations from the MWWTP occurs in Paradise Creek.

For 9/93 to 9/96 data set (MWWTP, 1997) calculations for fecal coliform show:

Washington Water Quality Std.	100 cfu/100 ml
Average Concentration	44 cfu/100ml

Geometric Mean Concentration	123 cfu/100ml
Average Flow	2.46 MGD
Average Load	4.19×10^{9} cfu/day
Load (based on geometric mean)	1.14×10^{10} cfu/day
Discharge flow limit proposed	4.0 MGD

Actual loads and loading capacity will change based on daily discharge variations. Adjusted to represent loading relative to the proposed 4.0 MGD permit limit, values are:

Load capacity	1.51×10^{10} cfu/day
Wasteload allocation (at 4.0 MGD)	1.51×10^{10} cfu/day
Daily Load (based on geometric mean)	1.85×10^{10} cfu/day
% Reduction necessary	18%

A reduction of approximately 3.4×10^{9} cfus/day or 18% reduction in load will be necessary to meet Washington State standards at the discharge to Paradise Creek.

Aquaculture Facility Load

Self-monitoring by the University of Idaho detected no fecal coliform presence in discharge water from the aquaculture facility. Load capacity and wasteload allocation (7.64×10^{8} cfus/day) are based on a discharge limit of 100 cfu/100 ml and 140 gpm design flow. No reductions in load are required.

Nonpoint Source Loading to Paradise Creek

Instream bacteria data (9/93 to 9/96) collected by the MWWTP (1996) at a point in Paradise Creek above the plant outfall was examined to estimate bacteria nonpoint source loading from the city of Moscow and the University of Idaho. Fecal coliform values are:

Washington Water Quality Std.	100 cfu/100 ml
Average Concentration	326 cfu/100 ml
Geometric Mean Concentration	401 cfu/100 ml
Average Flow	8.2 cfs
Average Load	6.22×10^{10} cfus/day
Load (based on geometric mean)	8.1×10^{10} cfus/day
Loading Capacity	2.02×10^{10} cfus/day
Load Allocation	2.02×10^{10} cfus/day

Actual loads and loading capacity will change based on daily flow variations. A reduction of approximately 6.08×10^{10} cfus/day or 75% reduction in load will be necessary to meet Washington Water Quality standards in Paradise Creek above the MWWTP outfall.

Fecal Coliform Allocations

Fecal coliform total wasteload allocations are 1.59×10^{10} cfus/day based on proposed discharge limits. The MWWTP allocation is 1.51×10^{10} cfus/day. Aquaculture facility allocation is 7.64×10^{8} cfus/day. The fecal coliform nonpoint source load allocation is variable depending on flow, but averages 2.02×10^{10} cfus/day based on the data sets examined. Average annual load capacity is 3.61×10^{10} cfus/day.

Margin of Safety

The margin of safety for the MWWTP and nonpoint sources is provided by using recent data and the geometric mean rather than the arithmetic mean. Because no fecal coliform is detectable from the aquaculture facility discharge, no numerical margin of safety is necessary. The loading capacity of the effluent is the wasteload allocation for the point sources.

3.5 AMMONIA

Targets

The proposed South Fork Palouse River TMDL for ammonia in Washington State would establish a chronic standard of 1.8 mg/l between November-March and 1.1 mg/l between April and October (Pelletier, 1993) at the Idaho-Washington state line. These targets are based on 4 day averages; 1 hour average target concentrations of 13.0 mg/l and 9.4 mg/l are proposed respectively for the same time periods mentioned above. Converted, the targets are 1.9 mg/l maximum daily and 0.9 mg/l average monthly limits for April through October; the targets are 2.9 mg/l daily and 1.5 mg/l monthly for November through March (Collins, 1997).

Idaho water quality standards include ammonia criteria that are intended to protect cold water biota. Idaho criteria for ammonia is based on calculations that take into account water temperature and pH; ammonia criteria are listed in tables III and IV of IDAPA 16.01.02. Washington state ammonia criteria that are being utilized are more stringent than the Idaho criteria.

The recommended four-day average target for total ammonia as N, based on the South Fork Palouse TMDL (Pelletier, 1993), is 1.1 mg/l from April through October. During this season, when warmest water temperatures occur, Idaho standards are less stringent than Washington's in a pH range of 6.5 to 7.8, at temperatures of 22°C or less. A nutrient study conducted for the Moscow Wastewater treatment plant from 6/92 to 7/95 showed recorded pH values ranged from 6.9 to 7.6 in Paradise Creek both above and below the MWWTP, with recorded creek temperatures up to 20.6°C. A similar comparison can be made for the November to March season and its recommended ammonia targets based on the same data set; at the temperatures and pH recorded for samples collected from Paradise Creek during these months, Washington State's 1.8 mg/l ammonia target is more stringent than Idaho's standard.

Ammonia (NH_3) is the form of nitrogen most readily taken up by aquatic organisms and may be an important contributor to eutrophication. Much of the ammonia present in water bodies is generated by bacteria as an end product in the anaerobic decomposition of organic matter (Wetzl, 1983). Ammonia is regulated because of its toxicity to aquatic organisms.

Ammonia dissolves in water to form the ammonium ion (NH_4^-), and exists in equilibrium as NH_3 and NH_4^+ and NH_4OH (ammonium hydroxide). Ammonia is harmful to aquatic organisms in small quantities (EPA, 1987). As pH and temperature increase, the percentage of total ammonia that exists as unionized ammonia increases. Ammonia is also an oxygen-demanding substance. Oxygen is consumed when bacteria convert ammonia to NO_3 through the process of nitrification. (Schnabel and Wilson, 1996).

Loads

Moscow Wastewater Treatment Plant

Effluent from the Moscow WWTP is the most significant source of ammonia to Paradise Creek. Data collected (6/92 to 7/95) from a station at the MWWTP outfall always exceeded the proposed target concentrations. Ammonia concentrations ranged from 1.2 mg/l to 10.6 mg/l (April-Oct) with an average concentration of 4.24 mg/l at the outfall. For the November to March time period, concentrations ranged from 2.8 mg/l to 9.7 mg/l with an average concentration of 6.13 mg/l. An average daily reduction in ammonia of approximately 80% is needed to meet Washington limits at the MWWTP outfall. A comparison of USGS daily flow records (10/86-9/95) for Paradise Creek vs typical MWWTP discharge volume (2.5 MGD) indicates that mixing zone flow requirements are usually (93% of the time) not met except during very high flow periods which occur primarily during February and March on Paradise Creek; hence, the recommended end-of-pipe discharge limits. Anticipated future population growth by the city of Moscow will likely push typical daily flow from the MWWTP toward the recommended 4.0 MGD permit limit. Mixing zone flow requirements are even less apt to be met in the future.

Schnabel and Wilson (1996) noted that during spring runoff (Jan-April), ammonia levels dropped to below target levels within a half mile below the MWWTP due to relatively high flow levels in Paradise Creek. In addition to dilution effects, ammonia-nitrogen may be taken up by bacteria, algae and aquatic macrophytes from late spring to early autumn. Although some ammonia is utilized in Paradise Creek below the MWWTP, ammonia is commonly present in sufficient quantities to contribute to eutrophication, dissolved oxygen depletion, and habitat degradation due to ammonia toxicity.

Aquaculture Facility

Ammonia levels were 0.1 mg/l or less for all samples reported. No reductions of ammonia will be required. Reported design flow rate was 140 gpm. Permit limits are end-of-pipe discharge limits. For general discussion of the aquaculture facility, refer to the NPDES Permitted Facilities section of this document.

Nonpoint Sources

Data collected at a station in Paradise Creek immediately above the MWWTP (6/92 to 7/95), shows no exceedances of the proposed targets for ammonia. Concentrations varied from below detection to 0.50 mg/l, averaging 0.08 mg/l from April through October. During November through March ammonia concentrations ranged from 0.04 to 1.28 mg/l; averaging 0.15 mg/l. Elevated levels of ammonia were detected in a separate study (Schnabel and Wilson, 1996) from July through September 1995 at the 6th and Deakin site 1.3 miles upstream but returned to concentrations below target levels at the above WWTP site.

Ammonia Allocations

Ammonia wasteload allocations total 29.9 lbs/day (April-Oct) and 49.9 lbs/day (Nov-March) based on proposed discharge limits. The MWWTP allocations are 28.5 lbs/day (April-Oct) and 47.5 lbs/day (Nov-March). Aquaculture facility allocations are 1.4 lbs/day (April-Oct) and 2.4 lbs/day (Nov-March). The ammonia nonpoint source load allocation is variable depending on flow, but averages 9.3 lbs/day (April-Oct) and 32.8 lbs/day (Nov-March) based on the data sets examined. Average load capacities are 41.3 lbs (April-Oct) and 87 lbs (Nov-March). Table 4 provides a summary of seasonal ammonia load allocations.

Table 4. Summary ammonia loading information:

Pollutant	Targets	Daily Average Concentration	Daily Average Load	Daily Average Load Capacity	Daily Allocation
Ammonia*					
NPS					
Apr-Oct.	0.9 mg/l	0.08 mg/l	0.6 lbs	9.8 lbs	9.3 lbs
Nov.-March	1.5 mg/l	0.15 mg/l	1.8 lbs	34.5 lbs	32.8 lbs
MWWTP					
Apr-Oct.	0.9 mg/l	4.24 mg/l	141.5 lbs	30 lbs	28.5 lbs
Nov.-March	1.5 mg/l	6.13 mg/l	205 lbs	50 lbs	47.5 lbs
Aquaculture					
Apr-Oct.	0.9 mg/l	<0.1 mg/l	<1.8 lbs	1.5 lbs	1.4 lbs
Nov.-March	1.5 mg/l	<0.1 mg/l	<1.8 lbs	2.5 lbs	2.4 lbs

For ammonia load calculations, disregarded sample results for 5/4/93. Extremely high flow values (5 times next highest values) significantly skewed loading upward. There is high variability for all loading data presented above due to day to day variabilities in flow. MWWTP load calculations are based on a 4.0 MGD proposed permit discharge limit.

Margin of Safety

A 5% margin of safety was applied to all sources.

3.6 LOADING SUMMARY

The loading capacity (LC) is effectively synonymous with the total maximum daily load (TMDL) for a waterbody. TMDL is defined as mass per unit time (ex. pounds per day) of pollutant allowed. The TMDL is the amount of pollutant that can enter the creek without exceeding the water quality target. Although the TMDL is defined in pounds per day or equivalent measurement, in practice compliance is measured as a concentration of pollutant in the creek (the water quality target) usually expressed in mg/l.

Wasteload allocations (WLA) are established for point sources and load allocations (LA) are determined for other sources. Load allocations are best estimates of the portion of the total load that can be contributed by nonpoint sources or by natural sources. When uncertainty exists (this is almost always the case) about the pollutant to water quality relationship, federal law requires a margin of safety (MOS) be included in the calculations. The MOS may be numerical or be incorporated in conservative assumptions used to establish the TMDL; the MOS is intended to insure that water quality goals will be met even though uncertainty in the loading capacity exists. The TMDL= WLA+LA+MOS.

Table 5 summarizes Paradise Creek TMDL water quality targets, pollutant load capacities, load allocations and margins of safety.

Table 5. Paradise Creek Pollutant Loading Summary

Pollutant	Instream Target	Discharge Limit	Mean Concentration	Load[3]	Load Capacity[4]	Wasteload Allocation[4]	Load Allocation	Margin of Safety	Reduction Needed (%)
Sediment(TSS)					**356 tons/yr**	**96 tons/yr**	**156 tons/yr**	**104 tons/yr**	
NPS	50 mg/l[1] over background for 10 cons. days		NA	1040 tons/yr	260 tons/yr		156 tons/yr	104 tons/yr	75%
MWWTP		15 mg/l	10.8 mg/l	67 tons/yr	91 tons/yr	91 tons/yr		C.A.[2]	none
Aquaculture		15 mg/l	<10 mg/l*	3 tons/yr*	5 tons/yr	5 tons/yr		C.A.[2]	none
Phosphorus (TP)	May 15-Oct 15	May 15-Oct 15			**5.6 lbs**	**4.7 lbs**	**0.9 lbs**		
NPS	0.136 mg/l		0.40 mg/l	2.2 lbs	0.9 lbs		0.9 lbs	C.A.[2]	59%
MWWTP		0.136 mg/l	7.16 mg/l	236 lbs	4.5 lbs	4.5 lbs		C.A.[2]	98%
Aquaculture		0.136 mg/l	0.13 mg/l	0.2 lbs	0.2 lbs	0.2 lbs		C.A.[2]	none
Fecal Coliform					**3.61×10^{10} cfu**	**1.59×10^{10} cfu**	**2.02×10^{10} cfu**		
NPS	100 cfu/100 ml		401 cfu/100 ml	8.1×10^{10} cfu	2.02×10^{10} cfu		2.02×10^{10} cfu	C.A.[2]	75%
MWWTP		100 cfu/100 ml	123 cfu/100 ml	1.85×10^{10} cfu	1.51×10^{10} cfu	1.51×10^{10} cfu		C.A.[2]	18%
Aquaculture		100 cfu/100 ml	not detectable	none	7.64×10^{8} cfu	7.64×10^{8} cfu		C.A.[2]	none
Temperature									
NPS	18°C[5]		NA	23°C[5]	18°C		18°C[5]	10%[6]	42%
MWWTP		18°C[5]		21°C[5]	18°C	18°C[5]		C.A.[2]	
Aquaculture		18°C[5]		13°C[5]	18°C	18°C[5]		C.A.[2]	
Ammonia					**41.3 lbs[7]**	**29.9 lbs[7]**	**9.3 lbs[7]**	**2.1 lbs[7]**	
NPS					**87 lbs[8]**	**49.9 lbs[8]**	**32.8 lbs[8]**	**4.3 lbs[8]**	
April-Oct.	0.9 mg/l		0.08 mg/l	0.6 lbs	9.8 lbs		9.3 lbs	5%	none
Nov.-March	1.5 mg/l		0.15 mg/l	1.8 lbs	34.5 lbs		32.8 lbs	5%	none
MWWTP									
April-Oct.		0.9 mg/l	4.24 mg/l	141.5 lbs	30 lbs	28.5 lbs		5%	80%
Nov.-March		1.5 mg/l	6.13 mg/l	205 lbs	50 lbs	47.5 lbs		5%	77%
Aquaculture									
April-Oct.		0.9 mg/l	<0.1 mg/l*	<1.8 lbs*	1.5 lbs	1.4 lbs		5%	none
Nov.-March		1.5 mg/l	<0.1 mg/l*	<1.8 lbs*	2.5 lbs	2.4 lbs		5%	none

[1] The TSS instream target is 50 mg/l above background concentration for 10 consecutive days, derived from Idaho's turbidity criteria via a site specific relation of TSS to turbidity.

[2] Used conservative assumptions (C.A.); these assumptions are discussed for each pollutant within section 3 of the text

[3] Except where otherwise indicated, loads are presented as daily averages. MWWTP loads are calculated using average daily concentrations from Discharge Monitoring Records and t proposed effluent limit of 4.0 Million Gallons per Day (MacInnis, 1997).

[4] MWWTP values are calculated using the proposed permit discharge limit of 4.0 MGD. Aquaculture Facility values are calculated based on 140 gpm design flow (Hutchison, 1997).

[5] Instantaneous value

[6] Added to current load for proposed load reductions (see Appendix B)

[7] April to October

[8] November to March

* Indicates detection levels of the reported monitoring. Actual concentrations and loadings are lower than the numeric values.

NA Mean concentration is not meaningful for NPS sediment due to variation in natural background. For temperature mean concentration and current load are synonymous in this analys

4.0 PUBLIC PARTICIPATION

Paradise Creek Watershed Advisory Group

IDAPA 16.01.02.052 provides requirements for public participation in water quality decisions. Basin Advisory Groups (BAGs) and Watershed Advisory Groups (WAGs) advise Idaho State on priority impaired waterbodies, management of impaired watersheds, and recommend pollution control activities in impaired watersheds.

The Paradise Creek Watershed Advisory Group (PCWAG) was appointed by the Administrator of the Idaho Division of Environmental Quality on December 10, 1996 to fulfill the public participation requirements of Idaho Code 39-3601 *et seq*. Under Idaho Code 39-3615, the Paradise Creek Watershed Advisory Group is charged with providing advice to the Idaho Division of Environmental Quality on the specific actions needed to control point and nonpoint source pollution impacting Paradise Creek water quality. Members selected for the PCWAG were recommended by the Clearwater Basin Advisory Group from nominations obtained from the local community to represent specific stakeholder groups within the watershed.

The PCWAG has been very successful in assisting the state in the development of the Paradise Creek TMDL. The group has provided the community's perspective of appropriate watershed management actions through cooperative discussions of issues, recommendations and advice. However, several community concerns remain with the Paradise Creek TMDL. These concerns are:

Flooding	Current and future water quality stream management efforts will need to incorporate concerns of potential flood risks within the Paradise Creek watershed.
Interstate Issues	Section 401 of the CWA states that in the case of interstate waters where state criteria differ, the standards of the downstream state must be met at the border. The PCWAG believes the Washington State water quality standards for Paradise Creek are exceedingly high.
Sediment Target	The Watershed Advisory Group is supportive of a narrative target for sediment but is uncomfortable with a numeric target. The Group has advised the Division to provide TMDL implementation provisions which allow a variance from the numeric target when Paradise Creek is shown to provide full support for beneficial uses and the numeric target has not been met.
Nutrient Target	The Paradise Creek Watershed Advisory Group disagrees with the interim phosphorus target proposed. Meeting the phosphorus target will require expensive phosphorus treatment at the Moscow waste water treatment plant or no discharge of effluent to Paradise Creek during the late summer

low flow period. The Watershed Advisory Group advises the Division that it is more economical and socially acceptable to pursue incremental reductions in phosphorus loads from the waste water treatment plant and determine the need for subsequent load reductions based on future water quality monitoring results.

The Paradise Creek Watershed Advisory Group met at least monthly and on more than one occasion twice monthly. The meetings were held in the City of Moscow Council Chambers and were open to the public and typically well attended.

The Idaho Division of Environmental Quality would like to thank each and every member of the Paradise Creek Watershed Advisory Group. The challenge is not a easy task, the desire and ability to participate is admirable and the Idaho Division of Environmental Quality commends their efforts.

Public Comments

The Paradise Creek Draft TMDL was made available for public review and comment November 5, 1997 through December 5, 1997. Notification to the general public of the opportunity to comment on the draft TMDL was made in the Moscow Pullman Daily News and the Lewiston Tribune. The draft TMDL was made available for public review at the Lewiston Regional DEQ office, the Moscow City Library, the University of Idaho Library, the Moscow City Hall, the Palouse Clearwater Environmental Institute, and the Latah Soil and Water Conservation District. Copies also were provided to a number of individuals upon request.

5.0 REFERENCES

Ada County Highway District and Other Co-applicants, 1997. Draft NPDES Municipal Storm Water Permit Application. Prepared by Woodward-Clyde Consultants.

Agricultural Research Service. 1997. Watershed Erosion Prediction Model. USDA Agricultural Research Service in cooperation with the National Soil Erosion Research Laboratory, West Lafayette, IN.

Alwin, J.A. 1984. Between the Mountains: A Portrait of Eastern Washington. Northwest Panorama Publishing, Bozeman, Montana.

Boucher, P.R., 1970. Sediment Transport by Streams in the Palouse River Basin, Washington and Idaho, July 1961 - June 1865. Geological Survey Water-Supply Paper 1899-C.

Brown, G.W., 1969. Predicting temperatures on small streams. *Water Resources Research* 5(1): 68-75.

Bush, J., 1997. University of Idaho, Geology Department. Personal Communication.

Bush, J., 1996. The Geologic History of Moscow and a Model for Moscow's Ground Water Recharge. A Non-Referenced Generalized Discussion.

Cardwell, J. 1997. Idaho Division of Environmental Quality. Personal Communication.

Chandler, R.D., 1994. Estimating annual urban nonpoint pollutant loads. Journal of Management in Engineering 10(6): 50-59 .

Clark, Greg, 1997. Personal communication. United States Geological Survey, Boise District Office, Boise, Idaho.

Collins, K., 1997. US EPA, Region 10. Memos to W. Dansart and to M. Letourneau.

Dansart, B. 1997. Simple Method Model Run for the City of Moscow, Idaho. Unpublished report. Idaho Division of Environmental Quality. Lewiston Regional Office.

Doke, J. and G. Hashmi. 1994. Paradise Creek Watershed Characterization Study. Washington State University, Pullman, Washington.

Dunne, T. and L.B. Leopold. 1978. *Water in Environmental Planning*. W.H. Freeman and Company, New York. 817 pg.

Edwards, D. 1997. Idaho Division of Environmental Quality. Personal Communication.

Elliot, W.J., Graves, S.M., Hall, D.E. 1997. Technical Documentation to the cross-drain spacing/sediment yield application (x-drain). Draft General Technical Report. Moscow ID: USDA Forest Service, Rocky Mountain Research Station

EPA, 1987. Quality criteria for Water 1986. EPA 440/5-86-001. USEPA, Office of Water, Regulations and Standards, Washington, DC.

Ferrin, S., 1997. University of Idaho Capitol Planning. Personal communication.

Flanagan, D.C., S.J. Livingston. 1995. WEPP User Summary. NSERL Report No. 11, W. Lafayette, IN: National Soil Erosion Research Laboratory. 131 pp.

Greene, K.E., Munn, M.D., and J.C. Ebbert. 1996. Nutrients, Benthic Algae, and Stream Quality During Low Streamflow in the Palouse River Basin, Washington and Idaho. US Geological Survey Water Resources Investigations Report 96-4078.

Grupp, C., 1997. University of Idaho Provost Office. Written comments received on draft Paradise Creek Water Body Assessment.

Guy, H.P., 1970. Fluvial sediment concepts. Techniques of Water-Resources Investigations of the USGS, Applications of Hydraulics, Book 3, Chapter C1.

Hallock, D. 1993. South Fork Palouse River Analysis of Ambient Monitoring Data. Ambient Monitoring Section, Washington State Department of Ecology, Olympia, Washington.

Hankley, D., 1997. Idaho Soil Conservation Commission. Personal communication.

Haselhuhn, R. 1994. Moscow Wastewater Treatment Plant, Moscow, Idaho. Personal Communication.

Heany, J.P. and Huber, W.C., 1979. Nationwide cost of wet-weather pollution control. Journal of the Water Pollution Control Federation 51(8): 2043-2053

Hibbs Analytical Laboratory. 1992-1995. City of Moscow Wastewater Treatment Plant Nutrient Data. Moscow Wastewater Treatment Plant, Moscow, Idaho.

Hutchison, F. 1997. University of Idaho Safety Office. Personal Communication.

IDHW. 1996. Idaho Water Quality Standards and Wastewater Treatment Requirements.

IDHW-DOE. 1981. Water Quality Status Report: S.F. Palouse River/Paradise Creek, Water Year 1980.

IDHW-DEQ. 1989. Idaho Water Quality Status Report and Nonpoint Source Assessment.

IDHW-DEQ. 1989. Technical Review of Sediment Criteria. Water Quality Report.

IDHW-DEQ. 1994-1996. Beneficial Use Reconnaissance Project assessments for Paradise Creek.

IDHW-DEQ. 1996. 1996 Water Body Assessment Guidance: A Stream to Standards Process.

IDHW-DEQ. 1996. The Middle Snake River Watershed Management Plan, Phase 1 TMDL, Total Phosphorus.

Joy, J. 1987. A Water Quality Assessment and Receiving Water Survey of the South Fork Palouse River at Pullman. Report to Washington Department of Ecology. Water Quality Investigations Section, Olympia, Washington.

Kimball Engineering, P.A. 1993. University of Idaho Campus Smoke Test Report prepared for the City of Moscow. Post Falls, ID.

Kimball, J. 1997. Memo to Paradise Creek Watershed Advisory Group.

Kjelstrom, L.C., M.A.J. Stone, and W.A. Harenberg. Statistical Summaries of Streamflow Data for Selected Gaging Stations in Idaho and Adjacent States Through September 1990-Volume1: Gaging Stations with 10 or More Years of Record. U.S. Geological Survey Water Resources Investigations Report 94-4069.

Kjelstrom, L.C. and Moffatt, R.L., 1981. A method of estimating flood-frequency parameters for streams in Idaho. USGS, Open File Report 81-909.

Klemm, D.J. *et al.* 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. EPA/600/4-90/030.

Krenkel, P.A., and Novotny, V., 1980. Water Quality Management. Academic Press, Inc., NY, 671 pp.

Latah Soil Water Conservation District (SWCD), 1981 and 1986. Idaho Agricultural Water Quality Program grant proposals.

Letourneau, M. 1997. Personal Communication. USEPA, Region 10, Seattle, WA.

Leopold, L.B., Wolman, M.G., and Miller, J.P., 1964. Fluvial processes in geomorphology. Dover Publications, Inc., New York

Lockwood, P., 1996. Analysis of Downhole Dissolved Oxygen Measurements in Shallow Aquifers Near Moscow, Idaho. Master of Science Thesis, College of Graduate Studies, University of Idaho.

LTI-Limno Tech. Inc. 1993. Draft Development of a Demonstration Total Maximum Daily Load for Paradise Creek. Prepared for United States Environmental Protection Agency, Region 10.

MacInnis, J., 1997. Written communication.

Mann, H. 1997. Idaho Division of Environmental Quality. Personal Communication.

Manson, A.R., 1997. Personal communication. University of Idaho - Department of Mathematics, Division of Statistics. Moscow, Idaho.

Marsalek, J. 1978. Pollution due to urban runoff: unit loads and abatement measures, Pollution from Land Use Activities Reference Group, International Joint Commission, Windsor, Ontario.

McCool, D., 1997. USDA Agricultural Research Service, Pullman, WA. Personal communication.

Moscow Wastewater Treatment Plant (MWWTP), 1997, Discharge Monitoring Records.

Munn, R.E., 1966. *Descriptive Micrometeorology*. Academic Press Inc., New York.

Newcombe C.P. and J.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. *North American Journal of Fisheries Management* 16: 693-727 pp.

Novotny, V. and Olem, H., 1994. Water Quality: prevention, identification, and management of diffuse pollution. Van Nostrand Reinhold, New York, 1054 pp.

Palouse-Clearwater Environmental Institute. 1990. Paradise Creek Adopt-A-Stream Project List.

Palouse-Clearwater Environmental Institute. 1994. Paradise Creek Restoration Project.

Palouse Conservation District. 1997. Paradise Creek Watershed Water Quality Management Plan.

Pankuk, C., 1997. USDA Agricultural Research Service, Pullman, WA. Personal communication.

Patmont, C.R., Pelletier, G.J., Singleton, L.R., Soltero, R.A., Trial, W.T. and Welch, E.B., 1987. The Spokane River Basin: Allowable Phosphorus Loading. Prepared for State of Washington Department of Ecology.

Pelletier, G.J. 1993. South Fork Palouse River Total Maximum Daily Load of Ammonia. Watershed Assessment Section, Washington Department of Ecology, Olympia, Washington.

Pierce, 1996. Geology of the Moscow East and Robinson Lake Quadrangles. Unpublished Thesis in progress, University of Idaho.

Plaskon, J., 1997. City of Moscow Planning. Personal communication.

Platts, W.S. 1971. The effects of logging and road construction on the aquatic habitat of the South Fork Salmon River, Idaho; Testimony at U.S. Senate hearings on *Clearcutting practices on national timberlands*, pp. 113-115.

Platts, W.S., Megahan, W.F., and Minshall, G.W., 1983. Methods for evaluating stream, riparian, and biotic conditions. Intermountain Forest and Range Experimental Station Ogden Utah. General Technical Report INT-138.

Rabe, F., L. Cazier, A. Thornbrough, J. Shuman, C. Luce, and J. Bell. 1993. Habitat Assessment and Bioassessment of Paradise Creek and South Fork of the Palouse River at Selected Sites in Idaho and Washington: 1992-1993. Aquatics Unlimited, Moscow, Idaho.

Reid L.M. and Dunne, T., 1996. Rapid Evaluation of Sediment Budgets. Catena Verlag GMBH, Germany.

Rosgen, D. 1994. A Classification of Natural Rivers. Cantena, Vol 22: 169-199. Elsevier Science, B.V.Amsterdam.

Schnabel, I.D., and Wilson, G.A. 1996. Water Quality Monitoring on the Idaho Section of Paradise Creek, August 1994-November 1995.

Simpson, J. and R. Wallace. 1982. Fishes of Idaho. The University Press of Idaho. Moscow, ID.

Smith O.R. 1940. Placer mining silt and its relation to salmon and trout on the Pacific Coast. *Transactions of American Fisheries Society*. Vol 10: 97 pp.

Soil and Water Conservation Society, 1992. RUSLE user's guide. Version 1.05pre_e, SWCS, Snkeny, IA

Soltero, R.A., Cather, M.R., McKee, K.O., Merrill, K.R. and Nichols, D.G., 1986. Variable Initiation and Termination of Alum Addition at Spokane's Advanced Wastewater Treatment Facility and the Effect on the Water Quality of Long Lake, Washington. Completion report for the City of Spokane.

Steiner, F., D. Osterman, M.Ellis, F. Ide, A.O'Leary, E. Pederson, S. Wall, J.Buckland, G.Christensen, S. Glasoe. 1985. Paradise Creek Watershed; Ecological Inventory, Suitability Analysis and Landscape Plan. Washington State University, Pullman, Washington.

Thurow, R. 1997. US Forest Service Research Station, Boise, ID. Personal communication.

Thornbrough, A.R. 1993. An Inventory of Pipes Discharging into Paradise Creek. Palouse Clearwater Environmental News Quarterly, Vol. 4(2): pp 9,12.

U.S. Department of Agriculture; Natural Resource Conservation Service. 1995. Preliminary Investigation Report for the Paradise Creek Watershed.

U.S. Department of Agriculture; Soil Conservation Service, University of Idaho, College of Agriculture, Idaho Soil Conservation Commission. 1981. Soil Survey of Latah County Area, Idaho.

U.S. Environmental Protection Agency. 1993. "Paradise Creek Waterbody Assessment-Draft." EPA, Boise, Idaho.

U.S. EPA, 1992. Guidance Manual for Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems. EPA 833-B-92-002. Washington, D.C.

U.S. Environmental Protection Agency. 1986. Quality Criteria for Water. EPA, Washington DC.

U.S. EPA, 1985. Water quality assessment: a screening procedure for toxic and conventional pollutants in surface and groundwater-part 1.

U.S. EPA, 1983. Results of the nationwide urban runoff program. Vol. 1-final report. Water Planning Division. NTIS PB84-18552. Washington, DC.

U.S. Geological Survey, 1986-1996. Annual Water Records for Idaho.

Washington State University, Institutional Research Office. 1993. Annual Average Headcount Enrollments. Washington State University, Pullman, Washington.

Wertz, L.B. 1997. Idaho Division of Environmental Quality. Personal communication.

Wertz, L.B. 1993. "Beneficial Use Attainability Assessment Work Plan: Paradise Creek, Latah County, Idaho." Idaho Department of Health and Welfare Division of Environmental Quality.

Western Watershed Analysts. 1997. Paradise Creek Headwaters Erosion and Sediment Delivery. For Bennett Lumber Company. Moscow, Idaho. 10 pp.

Wierenga, R., J. Schnabel, C. Christian, and C. Buckley. 1995. Diurnal Fluctuations of Biochemical Oxygen Demand and Dissolved Oxygen in Paradise Creek as Water Quality Indicators. Report for Civil Engineering 515, Dr. Donald Johnstone, Washington State University, Pullman, Washington.

Acronyms/Abbreviations

ACRONYM OR ABBREVIATION	FULL NAME
ARS	Agricultural Research Station
ASCE	American Society of Civil Engineers
BAG	Basin Advisory Group
BMP or BMPs	Best Management Practice or Best Management Practices
BOD or BOD5	Biological Oxygen Demand or 5-day Biological Oxygen Demand
BURP	Beneficial Use Reconnaissance Project
°C	degrees celsius
CAFO	Confined Animal Feeding Operations
CBOD	Carbonaceous Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFO	Confined Feeding Operations
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony forming units
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DEQ	Division of Environmental Quality
DO	Dissolved Oxygen
DMR or DMRs	Discharge Monitoring Report or Discharge Monitoring Reports
EHS	Extremely Hazardous Substances
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPT	Ephemeroptera, Plecoptera, Trichoptera Insect Orders
ESA	Endangered Species Act
ft	feet
FY	Fiscal Year
GIS	Geographic Information System
ha	hectare
HI	Habitat Index
HUC or HUCs	Hydrologic Unit Code or Hydrologic Unit Codes

ACRONYM OR ABBREVIATION	FULL NAME
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Division of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDHW	Idaho Department of Health and Welfare
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources
kg	kilogram
l	liter
LA	Load Allocation
lbs	pounds
LC	Loading Capacity (which = TMDL = Assimilative Capacity)
LUST	Leaking Underground Storage Tank
MBI	Macroinvertebrate Biotic Index
MGD	million gallons per day
m	meter
mg	milligrams
mg/l	milligrams per liter
ml	milliliter
MOS	Margin of Safety
µg	microgram
µg/l	micrograms per liter
MWWTP	Moscow Waste Water Treatment Plant
NAWQA	National Agriculture Water Quality Assessment
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
NTU	nephelometric turbidity unit
PCEI	Palouse Clearwater Environmental Institute
PNRS	Pacific Northwest River System (EPA Numbering System)
RCWP	Rural Clean Water Project
RM or R.M.	USGS River Mile

ACRONYM OR ABBREVIATION	FULL NAME
SARA	Superfund Amendments and Reauthorization Act of 1986
SAWQP	State Agricultural Water Quality Program
SCC	Soil Conservation Commission
SCD or SCDs	Soil Conservation District or Soil Conservation Districts
SCS	Soil Conservation Service
SFPR	South Fork of the Palouse River
SSOCs	Stream Segments of Concern
SWCD	Soil Water Conservation District
SWWRC	State of Washington Water Research Center
T/yr	Tons per year
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TPQ	Threshold Planning Quantity
TSS	Total Suspended Solids
UAA	Use Attainability Assessment
U of I	University of Idaho
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
WAC	Washington Administrative Code
WAG	Watershed Advisory Group
WBAG	Water Body Assessment Guidance
WLA	Waste Load Allocation
WMP	Watershed Management Plan
WQLS	Water Quality Limited Segment
WSU	Washington State University
WWTP	Wastewater Treatment Plant
yr	year

GLOSSARY

Alevin - Newly hatched salmonid still dependent on yolk sac; remains in stream bed gravel until yolk sac is absorbed.

Aeration - a process by which a water body secures oxygen directly from the atmosphere, the gas then enters into biochemical oxidation reactions in water.

Anadromous - Fishes, such as salmon and sea-run trout, that live part or the majority of their lives in the salt water but return to fresh water to spawn.

Aquifer - a water-bearing bed or stratum of permeable rock, sand, or gravel capable of yielding considerable quantities of water to wells or springs.

Adsorption - the adhesion of one substance to the surface of another; clays, for example, can adsorb phosphorus and organic molecules.

Aerobic - describes life or processes that require the presence of molecular oxygen.

Algae - small aquatic plants that occur as single cells, colonies, or filaments.

Alluvial - unconsolidated recent stream deposition.

Ambient - surrounding, external, or unconfined conditions.

Anaerobic - describes processes that occur in the absence of molecular oxygen.

Anoxia - the condition of oxygen deficiency

Antidegradation - A federal regulation requiring the States to protect high quality waters. Waters standards may be lowered to allow important social or economic development only after adequate public participation. In all instances, the existing beneficial uses must be maintained.

Aquatic - growing, living, or frequenting water.

Assimilative Capacity - an estimate of the amount of pollutants that can be discharged to and processed by a waterbody and still meet the state water quality standards. It is the equivalent of the Loading Capacity which is the equivalent of the TMDL for the waterbody.

Autotrophic - an ecosystem is considered autotrophic if the majority of the energy required for growth and maintenance of organisms is produced by plants within the system.

Basalt - a fine-grained, dark-colored extrusive igneous rock.

Bedload - material, generally of sand size or larger, carried by a stream on or immediately above (3") its bed.

Beneficial uses - any of the various uses which may be made of the water of an area, including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, navigation, recreation in and on the water, wildlife habitat, and aesthetics.

Benthic organic matter - the organic matter on the bottom of the river.

Benthic - pertaining to or living on the bottom or at the greatest depths of a body of water.

Benthos - macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate.

Best Management Practice (BMP) - a measure determined to be the most effective, practical means of preventing or reducing pollution inputs from point or nonpoint sources in order to achieve water quality goals.

Biochemical oxygen demand (BOD) - the rate of oxygen consumption by organisms during the decomposition (= respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

Biomass - the weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Biomass Accumulation - a measure of the density and lateral and downstream extent of plant growth across a waterbody.

Biota - All plant and animal species occurring in a specified area.

Cfs - cubic feet per second, a unit of measure for the rate of discharge of water. One cubic foot per second is the rate of flow of a stream with a cross section of one square foot which is flowing at a mean velocity of one foot per second. It is equal to 448.8 gallons per minute, 0.646 million gallons per day, or 1.98 acre-foot per day.

Coliform bacteria - a group of bacteria predominantly inhabiting the intestines of man and animal but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.

Colluvium - material transported to a site by gravity.

Decomposition - the transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

Designated Beneficial Use or Designated Use - Those beneficial uses assigned to identified waters in Idaho Department of Health and Welfare Rules, Title 1, Chapter 2, "Water Quality Standards and Wastewater Treatment Requirements:, Sections 110. through 160. and 299., whether or not the uses are being attained.

Dissolved oxygen - commonly abbreviated D.O., it is the amount of oxygen dispersed in water and is usually expressed as mg/L (ppm). The amount of oxygen dissolved in water is affected by temperature, elevation, and total dissolved solids.

Ecology - scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.

Ecosystem - a complex system composed of a community of flora and fauna taking into account the chemical and physical environment with which the system is interrelated; ecosystem is usually defined to include a body of water and its watershed.

Effluent - a discharge into the environment; often used to refer to discharge of untreated , partially treated, or treated pollutants into a receiving water body.

Environment - collectively, the surrounding conditions, influences, and living and inert matter that affect a particular organism or biological community.

Eolian - windblown

Erosion - the wearing away of areas of the earth's surface by water, wind, ice, and other forces. **Culturally-induced erosion** is that caused by increased runoff or wind action due to the work of man in deforestation, cultivation of the land, overgrazing, and disturbance of the natural drainage; the excess of erosion over that normal for the area.

Eutrophic - from Greek for "well-nourished," describes a body of water of high photosynthetic activity and low transparency.

Eutrophication - the process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a body of water. If the process is accelerated by man-made influences, it is termed cultural eutrophication. Eutrophication refers to natural addition of nutrients to waterbodies and to the effects of artificially added nutrients.

Existing Beneficial Use or Existing Use - Those beneficial uses actually attained in waters on or after November 28, 1975, whether or not they are designated for those waters in Idaho Department of Health and Welfare Rules, Title 1, Chapter 2, "Water Quality Standards ad Wastewater Treatment Requirements."

Fecal Streptococci - a species of spherical bacteria including pathogenic strains found in the intestines of warm blooded animals.

Feedback Loop - a component of a watershed management plan strategy that provides for accountability on targeted watershed goals.

Flow - the quantity of water that passes a given point in some time increment.

Gradient - the slope of the stream bed profile.

Granitic - derived from granite; coarse to medium grained intrusive igneous rock

Groundwater - water found beneath the soil's surface; saturates the stratum at which it is located; often connected to surface water.

Growth Rate - the amount of new plant tissue produced per a given time unit of time. It is also a measure of how quickly a plant will develop and grow.

Habitat - a specific type of place that is occupied by an organism, a population or a community.

Headwater - the origin or beginning of a stream.

Hydrologic basin - The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area. There are six basins described in the Nutrient management Act (NMA) for Idaho -- Panhandle, Clearwater, Salmon, Southwest, Upper Snake, and the Bear Basins.

Hydrologic cycle - the circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Runoff, surface water, groundwater, and water infiltrated in soils are all part of the hydrologic cycle.

Impervious - a surface, such as a pavement, that rain cannot penetrate.

Influent - the flow into a process, facility, or larger body of water

Inorganic - materials not containing carbon and hydrogen, and not of biologic origin.

Irrigation return flow - surface and subsurface water which leaves the field following the application of irrigation water.

LA - Load allocation for nonpoint sources.

Land Application - a process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of disposal, pollutant removal, or groundwater recharge.

Limiting factor - a chemical or physical condition that determines the growth potential of an organism, can result in less than maximum or complete inhibition of growth, typically results in less than maximum growth rates.

Limnology - scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.

Load Allocation - The amount of pollutant that nonpoint sources can release to a waterbody.

Loading - the quantity of a substance entering a receiving stream, usually expressed in pounds (kilograms) per day or tons per month. Loading is calculated from flow (discharge) and concentration.

Loading Capacity - the maximum amount of pollutant a waterbody can safely assimilate without violating state water quality standards. It is also the equivalent of a TMDL.

Loam - moderately coarse, medium and moderately fine-textured soils that include such textural classes as sandy loam, fine sandy loam, very fine sandy loam, silt loam, silt, clay loam, sandy clay loam and silty clay loam.

Loess -is defined as a uniform eolian (wind-blown) deposit of silty material having an open structure and relatively high cohesion due to cementation by clay or calcareous material at the grain contacts. A characteristic of loess deposits is that they can stand with nearly vertical slopes (ASCE P1826). Erosion potential is highly dependent on topography; ranges from low to very high within the Paradise Creek watershed.

Luxury Consumption - a chemical phenomenon in which sufficient nutrients are available in either the sediments or the water column of a waterbody, and the aquatic plants take up and store an abundance in excess of the plant's actual needs.

Macroinvertebrates - aquatic insects, worms, clams, snails, and other animals visible without aid of a microscope, that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

Macrophytes - rooted and floating aquatic plants, commonly referred to as water weeds. These plants may flower and bear seed. Some forms, such as duckweed and coontail (*Ceratophyllum*), are free-floating forms without roots in the sediment.

Margin of safety - an implicit or explicit component of water quality modeling that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody.

Mean - **the arithmetic mean** is the most common statistic familiar to most people. The mean is calculated by summing all the individual observations or items of a sample and dividing this sum by the number of items in the sample. The geometric mean is used to calculate bacterial numbers. The **geometric mean** is a back-transformed mean of the logarithmically transformed variables.

Meter - the basic metric unit of length; 1 meter = 39.37 inches or 3.28 feet.

Milligrams per liter (mg/L) - see parts per million.

Million gallons per day (MGD) - a unit of measure for the rate of discharge of water, often used to measure flow at WWTPs. It is equal to 1.55 cubic feet per second.

Monitoring - the process of watching, observing, or checking (in this case water). The entire process of a water quality study including: planning, sampling, sample analyses, data analyses, and report writing and distribution.

MOS - Margin of Safety. This accounts for any lack of knowledge concerning the relationship between pollutant loads and the water quality of the receiving waterbody. It is a required component of a TMDL and is often incorporated into the conservative assumptions used to develop the TMDL (generally within the calculations or models).

Mouth - the location where a water body flows into a larger waterbody.

National Pollution Discharge Elimination System (NPDES) - a national program from the Clean Water Act for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits to discharge pollutants to waters of the United States, including pretreatment requirements.

Nitrogen - a nutrient essential to plant growth, often in more demand than available supply.

Nonpoint Source - A dispersed source of pollutants such as a geographical area on which pollutants are deposited or dissolved or suspended in water applied to or incident on that area, the resultant mixture being carried by runoff into the waters of the state. Nonpoint source activities include, but are not limited to irrigated and non-irrigated lands used for grazing, crop production and silviculture; log storage or rafting; urban areas; construction sites; recreation sites; and septic tank disposal fields.

Nuisance - anything which is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient - an element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

Nutrient cycling - the flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic - "poorly nourished," from the Greek. Describes a body of water with low plant productivity and high transparency.

Organic matter - molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

Orthophosphate - a form of soluble inorganic phosphorus which is directly utilizable for algal growth.

Oxygen-demanding Materials - those materials, usually organic, in a waterbody which consume oxygen during decomposition or transformation. Sediment can be an oxygen-demanding material.

Parameter - a variable quantity such as temperature, dissolved oxygen, or fish population, that is the subject of a survey or sampling routine.

Partitioning - the sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times.

Pathogen- any disease-producing organism.

Periphyton - attached organisms, usually algae, growing on the bottom or other submersed substrates in a waterway.

pH - a measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral, and most lake waters range between 6 and 9. pH values less than 7 are considered acidic, and most life forms cannot survive at pH of 4.0 or lower.

Phased TMDL - A TMDL which identifies interim load allocations with further monitoring to gauge success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a waterbody. Under a phased TMDL, the TMDL has load allocations and wasteload allocations calculated with margins of safety to meet water quality standards.

Phosphorus - a nutrient essential to plant growth, typically in more demand than the available supply.

Phytoplankton - microscopic algae and microbes that float freely in open water of lakes and oceans.

Point source pollution - the type of water quality degradation resulting from the discharges into receiving waters from sewers and other identifiable "points." Common point sources of pollution are the discharges from industrial and municipal sewage plants.

Pretreatment - the reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a WWTP.

Primary productivity - the rate at which algae and macrophytes fix or convert light, water, and carbon dioxide to sugar in plant cells. Commonly measured as milligrams of carbon per square meter per hour.

Reach - a stream section with fairly homogenous characteristics.

Respiration - process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

Riffle – A shallow, gravelly area of stream bed with swift current.

Riparian - associated with aquatic (streams, rivers, lakes) habitats. Living or located on the bank of a waterbody.

Runoff - the portion of rainfall, melted snow, or irrigation water that flows across the surface or through underground zones and eventually runs into streams.

Sediment - bottom material in a body of water that has been deposited after the formation of the basin. It originates from remains of aquatic organism, chemical precipitation of dissolved minerals, and erosion of surrounding lands..

Settleable solids - the volume or weight of material that settles out of a liter of water in one hour.

Specific conductance - also known as specific conductivity. It is a numerical expression of the ability of an aqueous solution to carry electric current, expressed in μmhos/cm at 25°C. Conductivity is defined as the reciprocal of the resistivity normalized to a 1 cm cube of liquid at a specific temperature and is an indirect measure of dissolved solids.

Stagnation - the absence of mixing in a waterbody

Stochastic - of, or pertaining to, a process involving a randomly determined sequence of observations each of which is considered as a sample of one element from a probability distribution.

Stream Segments of Concern (SSOCs) - Stream segments nominated by the public and designated by a committee whose members are appointed by the Governor.

Storm water runoff - Surface water that washes off land after a rainstorm. In developed watersheds it flows off roofs and pavement into storm drains which may feed directly into the stream; often carries pollutants.

Sub-watershed - smaller geographic management areas within a watershed delineated for purposes of addressing site specific situations.

Suspended sediments - Fine mineral or soil particles that remain suspended by the current until deposited in areas of weaker current. They create turbidity and, when deposited, can cover fish eggs or alevins.

Thalweg - The center of the current.

Threatened species - a species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

TMDL - Total Maximum Daily Load. TMDL = LA + WLA + MOS. A TMDL is the equivalent of the Loading Capacity which is the equivalent of the assimilative capacity of a waterbody.

Total suspended solids (TSS) - the material retained on a 2.0 micron filter after filtration.

Tributary - a stream feeding into a larger stream or lake.

Trophic state - level of growth or productivity of a lake as measured by phosphorus content, chlorophyll a concentrations, amount of aquatic vegetation, algal abundance, and water clarity.

Turbidity - a measure of the extent to which light passing through water is scattered due to suspended materials. Excessive turbidity may interfere with light penetration and minimize photosynthesis, thereby causing a decrease in primary productivity. It may alter water temperature and interfere directly with essential physiological functions of fish and other aquatic organisms, making it difficult for fish to locate a food source.

Vadose zone - The zone containing water under less pressure than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below the surface of the zone of saturation, that is, the water table.

Wash Load - that part of the total sediment load composed of all particles finer than limiting size, which is normally washed into and through the reach under consideration without settling.

Waste Load Allocation - a portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. It specifies how much pollutant each point source can release to a waterbody.

Water column - water between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution - Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to fish and wildlife, or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality Limited Segment (WQLS) - any water body, or definable portion of water body, where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards.

Water Quality Management Plan - a state or areawide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water quality modeling - the input of variable sets of water quality data to predict the response of a lake or stream.

Water table - the upper surface of groundwater; below this surface the ground is saturated with water.

Watershed - a drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation. The whole geographic region contributing to a water body.

Wetlands - lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; and (3) the substrate is on soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

WLA - Wasteload Allocation for point sources.

APPENDIX A

PARADISE CREEK NONPOINT SOURCE SEDIMENT LOAD ANALYSIS AND ALLOCATIONS

Appendix A Paradise Creek Nonpoint Sediment Load Analysis and Allocations

Current Loads

<u>Nonpoint Source Load</u>

A nonpoint Total Suspended Solids (TSS) load for Paradise Creek was determined through instream measurements of TSS by the City of Moscow Waste Water Treatment Plant (MWWTP). A TSS/flow rating curve was developed based on these samples and instantaneous USGS flow. An average annual TSS load was determined using a TSS/flow curve for daily TSS and daily USGS flow data. TSS data used for rating curve development are from grab samples collected by the MWWTP over a seventeen year period. These data include instantaneous measurement of TSS at 8:00 AM, collected three times a week, year round, within the top six to twelve inches of the water column. Depth integrated samples, bedload data, and detailed streambed and streambank particle size distributions are not currently available. The TSS data collected are assumed to represent the smaller sized particles of the stream washload. The current sediment load values are based on this TSS data only.

The TSS grab samples used for the nonpoint sediment load estimates were collected upstream of the MWWTP in Paradise Creek (Figure A1). Daily and instantaneous streamflow data collected by the United States Geological Survey (USGS) were available a short distance upstream of this data collection site at the University of Idaho stream gage.

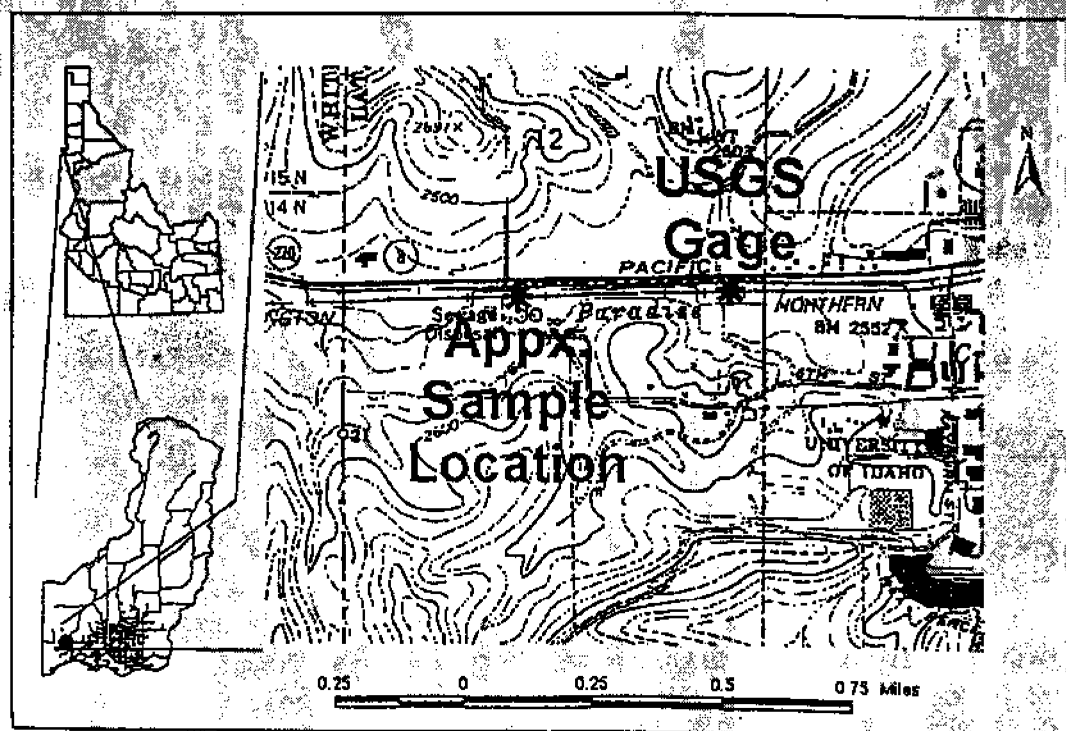


Figure A1. MWWTP and USGS Sample Locations

Average hourly flow values are available in electronic format for the period of record. Hourly flows, however, are published for the most recent 18 month period only. In addition to these data sources, archived hourly flow data can be obtained in hard copy from the USGS. A sub-set of archived instantaneous 8:00 AM flows were also made available ~~for this~~ analysis (Hankely, 1997).

A series of sediment rating curves were developed for each year over the period of record using the natural log of the TSS and the archived instantaneous flow data. An examination of how these sediment rating curves changed over the period of record is presented in Table A1. Correlation coefficients between ln(TSS) and ln(flow) for the 8:00 AM flow data set were consistent over the period of record.

Table A1. Statistical Summary of Annual Rating Curves, 1980-96

Water Year	R Square	Standard Error	Observations	Intercept	Slope of LN(FLOW)	Annual Precipitation (inches)	Average Ln(Flow)
1980	0.37	1.02	232	3.05	0.50	28.6	0.50
1981	0.42	0.85	252	2.68	0.51	27.1	0.38
1982	0.49	0.89	200	2.74	0.51	30.0	0.48
1983	0.57	0.62	165	2.32	0.48	29.3	0.73
1984	0.65	0.74	140	2.69	0.61	27.4	0.64
1985	0.52	0.80	131	2.51	0.56	23.4	0.68
1986	0.72	0.58	131	2.38	0.60	27.5	0.41
1987	0.63	0.76	135	2.62	0.87	21.8	0.10
1988	0.45	0.97	125	2.70	0.69	21.9	-0.03
1989	0.55	0.72	131	2.08	0.55	27.0	0.59
1990	0.69	0.72	140	1.88	0.76	25.4	0.71
1991	0.54	0.77	134	2.19	0.54	26.7	0.58
1992	0.51	0.84	145	2.21	0.68	24.8	-0.17
1993	0.67	0.75	144	2.03	0.63	24.8	0.57
1994	0.57	0.80	140	2.01	0.84	17.5	-0.37
1995	0.54	0.89	141	1.64	0.60		1.03
1996	0.70	0.88	142	1.96	0.65		0.90
1997	0.61	0.92	90	2.10	0.68		2.12
Total	0.51	0.91	2718	2.37	0.59		

A sediment rating curve based the TSS grab samples and the hourly flow data was developed in order to estimate the TSS over the entire USGS flow data period of record (Equation 1). The regression between the 8:00 AM grab samples and the 8:00 AM flow data allows an estimate of TSS exiting the basin for any given flow. It was assumed that no temporal autocorrelation was present within the data set due to the small drainage size of Paradise Creek upstream of the MWWTP.

The most recent 18 months of data were used for establishing the sediment rating curve used in the current TSS load analysis. This decision was based on the following rational: (1) the last 18 months would most likely be the most representative of current conditions; and (2) the 18 month data set covered the highest flows of the entire period, eliminating any extrapolation for loads during these flows.

$$C = 7.434 * Q^{0.676} \qquad \text{(A1)}$$

where C = TSS concentration (milligrams per lite (mg/l))
Q = flow (cubic feet per second (cfs))

Equation A1 is based on hourly flow and instantaneous TSS concentrations. In order to utilize daily average flow, an equation based on the daily average flow and daily average TSS concentrations was needed. It was noted that as the average daily flow increased, the standard deviation of the individual hourly flow values also increased. First, a TSS load was determined for each of the hourly intervals using the hourly USGS flow (Equation 1). These hourly TSS and hourly flow values were averaged for daily TSS and flow values. These average values were then plotted against each other for a final equation that relates the average daily flow and average daily TSS concentration (Equation A2). This equation better incorporates the increase in standard deviation from the hourly to the daily and more accurately predicts the average daily TSS load (Manson, 1997).

$$Load = [2.76 + (1.53\ Q_{avg}) - (0.0016\ Q_{avg}^2) + (1.14E\text{-}6\ Q_{avg}^3)]^2 \qquad \text{(A2)}$$

where Q_{avg} = daily average flow (cfs)
Load = daily average TSS load (mg/l)

Inserting the USGS average daily flow for the period of record into Equation A2 yields a total load of 19,376 tons for the seventeen years. This equates to approximately 1040 tons per year (T/yr) or 2.85 tons per day (T/day). Note that in order to utilize the entire flow it is assumed that the fine particles collected within the top 6 to 12 inches of the water column are uniformly distributed throughout the water column.

Figure A2 shows how Equation A2 compares to the observed load and flow relationship. Table A2 outlines the analysis of variance for the relationship.

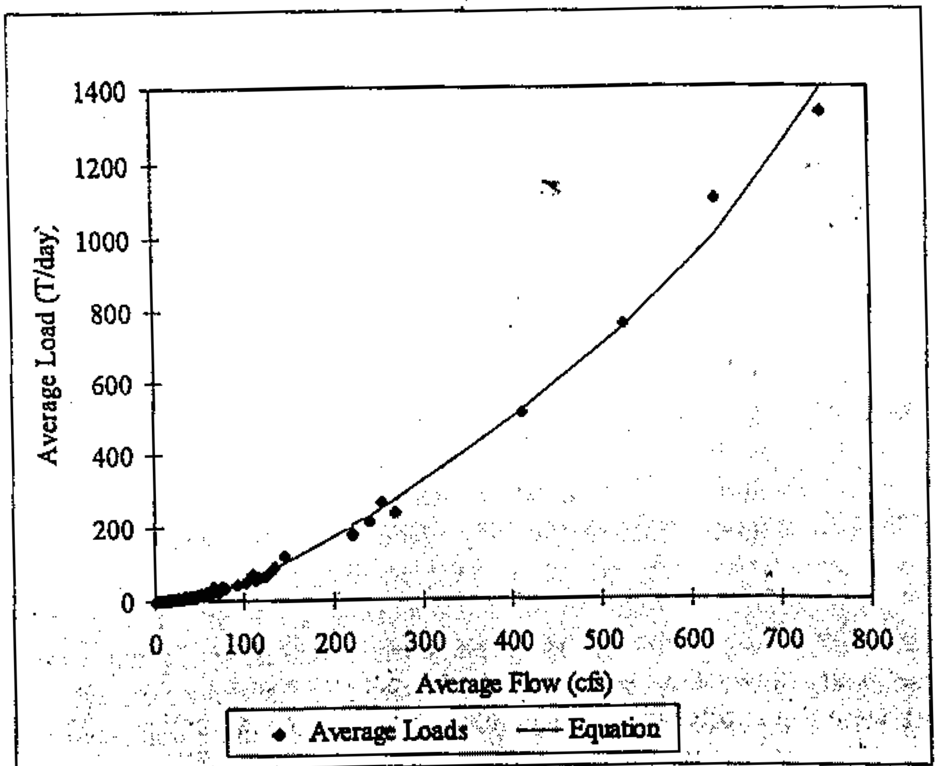


Figure A2. Daily Average TSS Load versus Daily Average Flow

Table A2. Equation A2 Analysis of Variance

Root MSE	3.42		R-Square	0.997	
Dep Mean	29.37		Adj R-Square	0.997	
C.V.	11.65				

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for HO: Parameter = 0	Prob > |T|
Intercept	1	2.76	1.79	15.4	0.0001
VAR1	1	1.53	9.38E-3	163.2	0.0001
VAR2	1	-1.60E-3	4.89E-5	-33.2	0.0001
VAR3	1	1.14E-6	6.00E-8	20.7	0.0001

Two different approaches were used to validate that the sediment load estimated with the MWWTP TSS data is less than the total sediment load in Paradise Creek. One approach was to compare TSS loads based on depth integrated samples found in similar basins within the Palouse regio. (Boucher, 1970) (Table A3). The other was to apply a particle size distribution for those sediments trapped in the stream channel and compare those distributions with sediments found in adjacent streambanks (Reid and Dunne, 1996) (Table A4, Figure A3).

A summary of sediment yields from adjacent basins is presented in Table A3. A comparison between these yields and what might be a yield for Paradise Creek based on relative basin size shows that the annual yield for Paradise Creek should be in the range of 15,000 to 37, 000 T/yr. This assumes similar geology, land use patterns, channel transport mechanisms among the basins examined.

Table A3. A Summary of Sediment Yields from Adjacent Basins (Boucher, 1970)

	Sediment Yield (T/yr)
South Fork of the Palouse River at Pullman	14700
Missouri Flat Creek at Pullman	35700
South Fork of the Palouse River - Pullman to Colfax	25200
South Fork of the Palouse River at Colfax	20580

Boucher's study was based on total suspended sediment depth integrated data and not total suspended solids data (used in the present analysis). Research comparing amounts of total suspended sediment with total suspended solids show that total suspended sediments may be twice as high as TSS for a given sample (Clark, 1997). This would indicate that the average annual load of total suspended sediments would be around 2080 T/yr. Comparing the TSS (total suspended solids) measured by the MWWTP to the total suspended sediment found in Boucher's study indicates that the TSS measured at the MWWTP may be around 6 - 14 percent of the total sediment load.

The second method used to validate that the TSS sediment load estimated from the MWWTP data is less than the total sediment load for Paradise Creek was a particle size analysis. Differences in grain size distributions between bank soils and stream deposits are thought to indicate the fraction available for suspended transport (Reid and Dunne, 1996). This fraction, also known as wash load, generally consists of very fine sand to coarse silt (0.062 millimeter (mm)). However, the size and amount of particle suspension also depends on grain shape and viscosity (Guy, 1970; Leopold et al., 1964).

Grain size analysis were conducted on soil samples collected in areas outside the stream channel and areas within the stream channel. A total of six samples were collected from various locations within the Paradise Creek watershed (Table A4). These samples were sieved through standard U.S. Sieves (8, 16, 18, 35, 60, 200, 230, and 300 (range 2.36 mm to 0.038 mm)) according to the analytical methods described by Platts et al. (1983).

Table A4. Statistical summary of the particle size analysis.

Site	Location	d16	d50	d84
Idler's Rest	Bank	0.038	0.25	2
Idler's Rest	Stream	0.038	0.074	0.25
Darby Road	Bank	0.035	0.23	1.5
Darby Road	Stream	<0.03	0.03	0.063
USGS Gage	Stream	<0.03	0.04	0.40
MWWTP	Stream	<0.03	0.08	0.5

Bank soil samples, with adjacent streambed samples, were collected from the upper watershed and mid-watershed areas. The upper watershed soil sites were at Idler's Rest, on the slopes of Moscow Mountain. The mid-watershed sample sites were located where Darby Road crosses Paradise Creek.

Results from the particle size analysis indicate 50 percent of the undisturbed soil sample particles are less than 0.25 mm (fine sand). The forested sample consists of gravel size granitic material, and the agricultural sample consists of cohesive loess gravel to sand size material. Based on composition, grains in the forested sample likely have a greater fall velocity, therefore, the agricultural sample inherently provides a greater proportion of suspended sediment (Guy, 1970).

The dominate grain size of streambed sediments were found to vary within the watershed (Figure A3) and seem to relate to the underlying geology. Near the headwaters, the Idler's Rest stream deposit sample is mainly medium to fine sand and consists of quartz and feldspar material. The stream deposit in the central portion of the watershed (Darby Road) is 84 percent coarse silt material and consists of Palouse loess material. Samples collected near the Idaho-Washington state line consist of a mix of loess, granite, and basalt material with a slightly coarser dominate particle size.

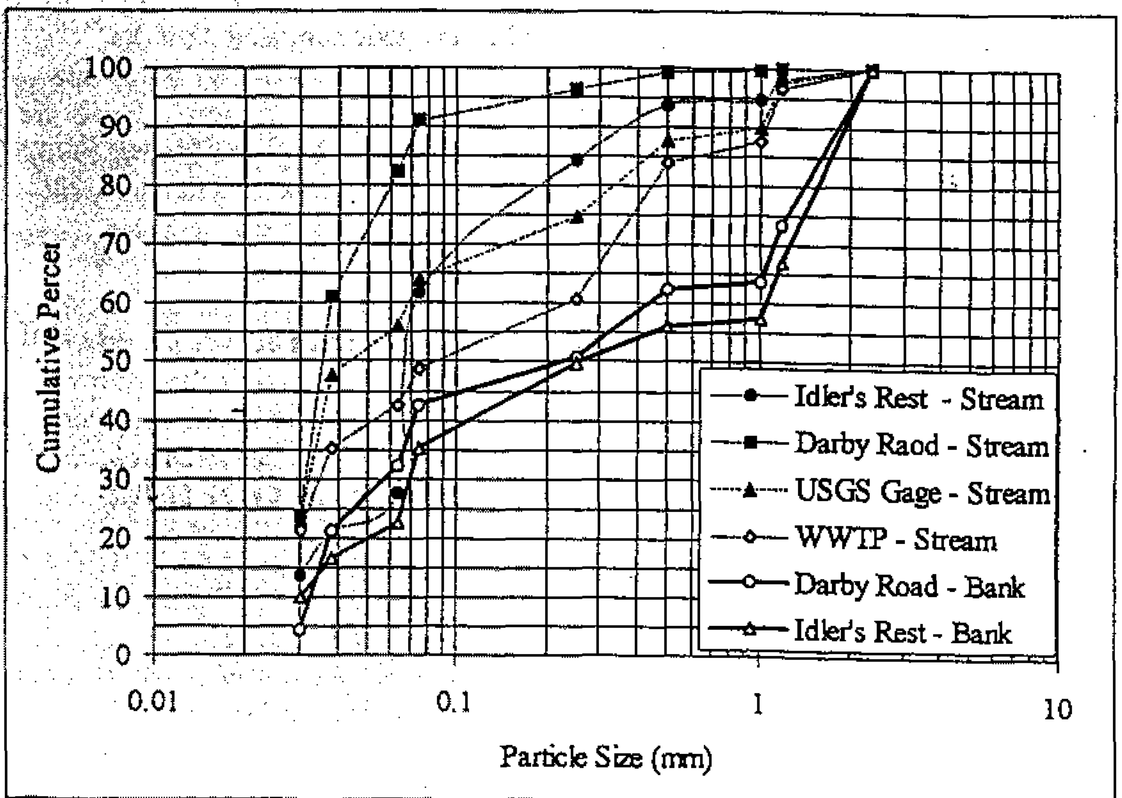


Figure A3. Cumulative Particle Size Plot of Paradise Creek Soil and Sediment Samples

As mentioned, the grain size distribution differences between bank soil and stream deposit samples were examined to validate whether the TSS sediment load estimated from the

MWWTP data is less than the total sediment load for Paradise Creek. Streambed and streambank samples collected in the upper portion (Idler's Rest) and the central portion (Darby Road) of the watershed have the same general degree of sorting.

Grain sizes greater than 0.25 mm constitute 30 to 50 percent of the bank material, while grain sizes less than 0.062 mm (coarse silt) make up 25 to 35 percent. Compared with the streambed material where 84 percent of the material is made up of large grain sizes, an estimated 30 percent of the finer material appears to have been transported downstream during flow events.

Given the non-homogenous particle distributions found along most gravel/sand dominated stream bottoms and the large influences adjacent geologies have on the particle size compositions, the error contained within this estimate may be great. Many more streambed and streambank samples would need to be collected in order to reduce the uncertainty of these estimations.

It is certain that the TSS measured underestimates the total load for Paradise Creek upstream of the MWWTP. Also, it appears that this underestimation between 70 and 97 percent (e.g. somewhere between 3 and 30 percent was measured in the top portion of the water column). This would place the total annual sediment load in the range of 3,500 tons to 35,000 tons.

The targeted reductions and sediment load values are based on TSS data only. While, sediment other than TSS may impact cold water biota, it is assumed that a reduction in TSS will ultimately reduce the total load delivered to Paradise Creek, thus reducing beneficial use impairment.

Natural Background Levels for Nonpoint TSS

The current water quality standards for turbidity are based on an increase over background levels. Background levels of a pollutant are defined in the State of Idaho Administrative Code as "The biological, chemical, or physical condition of waters measured at a point immediately upstream (up-gradient) of the influence of an individual point or nonpoint source discharge. If several discharges to the water exist or if an adequate upstream point of measurement is absent, the department (i.e. DEQ) will determine where background conditions should be measured." (IDAPA 16.01.02.003.07)

It may not be easy to select a site or sites to determine background conditions. Several sources of TSS for both point and nonpoint source discharge within the Paradise Creek basin. An adequate upstream point of measurement not present because of the varying geology present within the drainage. Therefore, in order to determine the nonpoint background levels of TSS for the Paradise Creek basin, the original land uses of prairie and forest were assumed and a plot scale erosion prediction model was applied.

The model selected for this analysis was the Water Erosion Prediction Project model

(WEPP) (Agricultural Research Service, 1997; Flanagan and Livingston, 1997). Erosion predictions were derived with WEPP based on characteristic topography, climate, and soils in conjunction with undisturbed prairie and forest conditions for the Paradise Creek basin. These were then compared with erosion predictions based on the same topography, climate, and soils in conjunction with current land use practices within the basin.

The differences in annual erosion rates from these model applications indicate that the overall background erosion rate is about 18 percent of the current erosion rate. This percentage is based on the amount of area within three general slope categories. The way that background is proportioned according to the various land uses, therefore, is based on the aerial extent of a particular land use.

Based on this analysis the background is considered to be 18 percent of the total TSS load. Thus, of the 1040 T/yr calculated by Equation A2, 853 T/yr was assumed to be above background or due to anthropogenic. Revisiting the flow and concentration data sets (8:00 AM flow and the MWWTP data), instantaneous loads were calculated for each sample, then multiplied by 0.18. These converted loads were then divided by flow to return an estimated background concentration. All of the samples then were grouped into several flow regimes, and the estimated background concentrations for each flow regime were averaged. Allowable increase over the estimated background for each flow regime are presented in Table A5. As can be seen, the TSS concentrations increase as flows increase due to background TSS concentrations.

Subsequently, the 10 day and instantaneous targets identified in the Paradise Creek TMDL document were applied to the MWWTP data set. Whenever values in the data set exceeded these targets, they were decreased to target concentrations. To illustrate, if the data set contained a TSS value of 397 mg/l for a flow of 68 cfs the instantaneous target would be 156 mg/l (Table A5). Also, when a continuous set of samples exceeded 50 mg/l plus background for longer than a 10 day period, the concentration on the 10^{th} day was dropped back to 50 mg/l plus background. By this method, an overall allowable load is determined before and after the instantaneous turbidity standard is applied.

Table A5. Background Concentrations at a Variety of Flows and Concentrations

Flow (cfs)	Estimated Background Concentration (mg/l)	Maximum 10 Day Concentration (mg/l)	Maximum Instantaneous Concentration (mg/l)
<1	0.1	50.1	100.1
1-5	0.4	50.4	100.4
5-10	1.3	51.3	101.3
10-20	2.5	52.5	102.5
20-50	5.3	55.3	105.3
50-150	14.7	64.7	114.7
150-250	34.5	84.5	134.5
250-500	56	106	156
500-750	111	161	211
750-1000	172	222	272

Applying the concentrations listed in Table A5 to the USGS daily flow data set allows the current TSS load estimated for Paradise Creek (1040 T/yr) to be broken down into background and allowable TSS loads. Of this load, 187 T/yr of TSS is attributed to natural background and 177 T/yr of TSS is attributed to loading allowed under the current TMDL sediment targets. Using a ten percent margin of safety the load capacity for nonpoint TSS is about 260 T/yr. This indicates that the current load exceeds the load capacity by 780 T/yr, or that the current nonpoint TSS load must be reduced by approximately 75 percent.

Proportioning the Nonpoint TSS Load

Proportioning the total nonpoint TSS load over the various sources (agriculture, forestry, urban, and county gravel roads) was conducted through the use of several models. Particular emphasis was given to WEPP, the Revised Universal Soil Loss Equation (RUSLE) (Agricultural Research Service, 1992; NRCS, 1995), and the Simple Method for urban runoff concentrations (EPA, 1983). The proportion of the current TSS load estimated by RUSLE (Hankely, 1997) and the Simple Method (Dansart, 1997) are included for comparison with those proportions estimated by WEPP.

WEPP is a stochastic, physically based, plot-scale model developed to assess field scale erosion rates. Climate, soils, and topography data specific to the sites are required for all WEPP model applications. The application of WEPP to the agriculture portion of the Paradise Creek watershed relied on representative characterizations of management practices, topographies, and soils.

The application of WEPP to the forested areas, a portion of the urban areas, and the county road portions of the basin relied on representative gravel and native soil road characteristics. Lengths of roads were determined with the aide of the City of Moscow

Planning department and others knowledgeable about the length, condition, and characteristics of the roads. It was assumed that the sediment erosion estimated by WEPP would enter the larger creek system and eventually leave the basin. Also, it was assumed that the TSS measured at the downstream point originated from all portions of the basin, except where sediment settling ponds eliminated that portion of the measured load. The method used in this analysis assumes that the channel material is a re-suspension of material already delivered to the larger creek system. This assumption is useful to estimate average annual loads over a long period of record. Therefore, channel erosion processes were not examined.

A user version of WEPP specific to forest roads (Cross-drain) was utilized for all of the road delivered sediment estimates (Elliot et al., 1997). Miles of road were obtained by examining aerial photos and reviewing a study by Western Watershed Analysts for Bennett Lumber Company (1997).

Erosion rates attributed to the urban portion of the sediment load were assigned to unpaved road surfaces and construction activities. Unpaved road surface erosion was estimated using Cross-drain (Elliot et al., 1997). Construction related erosion was estimated using WEPP. Acreage under construction were estimated based on a 5 percent growth rate for the City of Moscow. This acreage was then broken up into slope classes and associated topography for additional WEPP model runs. Soil profiles and ground cover associated with construction activities were used.

The relative proportions assigned by the various models to the various land uses were fairly consistent. Because WEPP lent itself to uniform application across the watershed the results from WEPP were used for the final overall load allocation. Table A6 shows the output of WEPP along with the estimate provided by the other models used. Tables A7 and A8 show the proportions of the current, background, and allocated load for nonpoint activities within Paradise Creek watershed. estimate of the contributions of these loads from the nonpoint land use activities within the basin and lists the percent reduction required for each land use to meet the sediment targets.

Table A6. Modeled Proportions of Nonpoint TSS Load by Land use

Land use	Percent of Anthropogenic Load	
	WEPP	Other[1]
Agriculture	83	86
Forest	4	2
Urban	5	4
County Roads	8	8

[1]Proportions for the Agriculture and Forest load are based on NRCS (1995) and Hankely (1997). Predictions for Urban load are based on EPA simple method (Dansart, 1997). Predictions for the county road load are based on WEPP and were included to compare proportions estimated by other models.

Table A7. Nonpoint TSS Load Proportioned by Land Use

Land use	Percent Current Load	Percent of Total Background Load*	Percent of Load Above Background
Agriculture	81	64	83
Forestry	7	23	4
Urban	5	12	5
County Roads	7	0.4	8

*Based on aerial extent of land use.

Table A8. Nonpoint TSS Load Proportioned by Land Use

Land use	Current Load (T/yr)	Load Capacity* (T/yr)	Proposed Reduction (T/yr)
Agriculture	842	195	647
Forestry	73	42	31
Urban	52	13	39
County Roads	67	5	62

*Load Capacity = Allowed WLA + Background - MOS

APPENDIX B

PARADISE CREEK
TEMPERATURE LOAD ESTIMATES

Appendix B: Paradise Creek Temperature Load Estimates

Current Stream Temperature

The stream temperature due to nonpoint activities in Paradise Creek was characterized using surface stream temperature measured upstream of the MWWTP at 8:00 AM. These measurements were taken within the top portion of the water column over a nineteen year period. This 8:00 AM data set is the most comprehensive stream temperature set available for Paradise Creek.

The stream temperature data show numerous exceedences of the current 18 °C target. A subset of these data shows how nonpoint related temperature exceedence commonly occur during the summer months (June - September) (Figure B1).

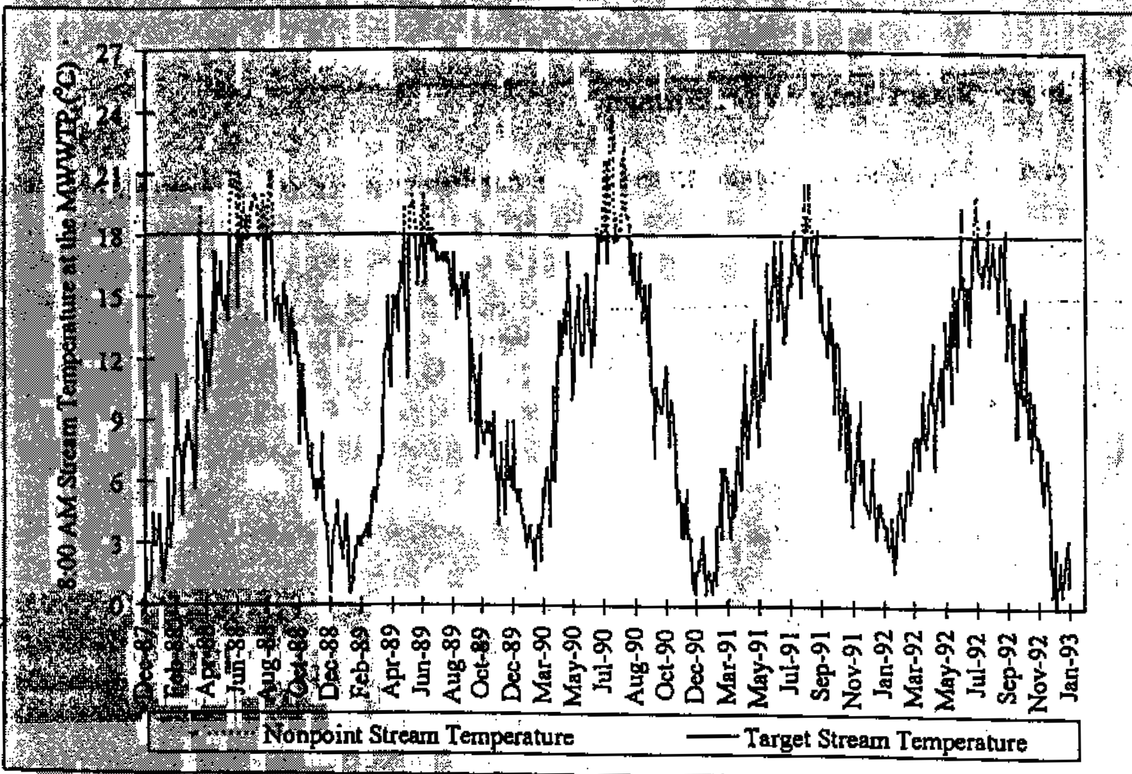


Figure B1: Target Stream Temperature Exceedences, 1988 - 1992

A histogram of summer observations (June through September) collected upstream of the MWWTP over the nineteen year period of record is shown in Figure B2. The average of these summer data is 15.8 °C, with a standard deviation of 3.1 °C. The 95th percentile for these 8:00 AM data is 21 °C.

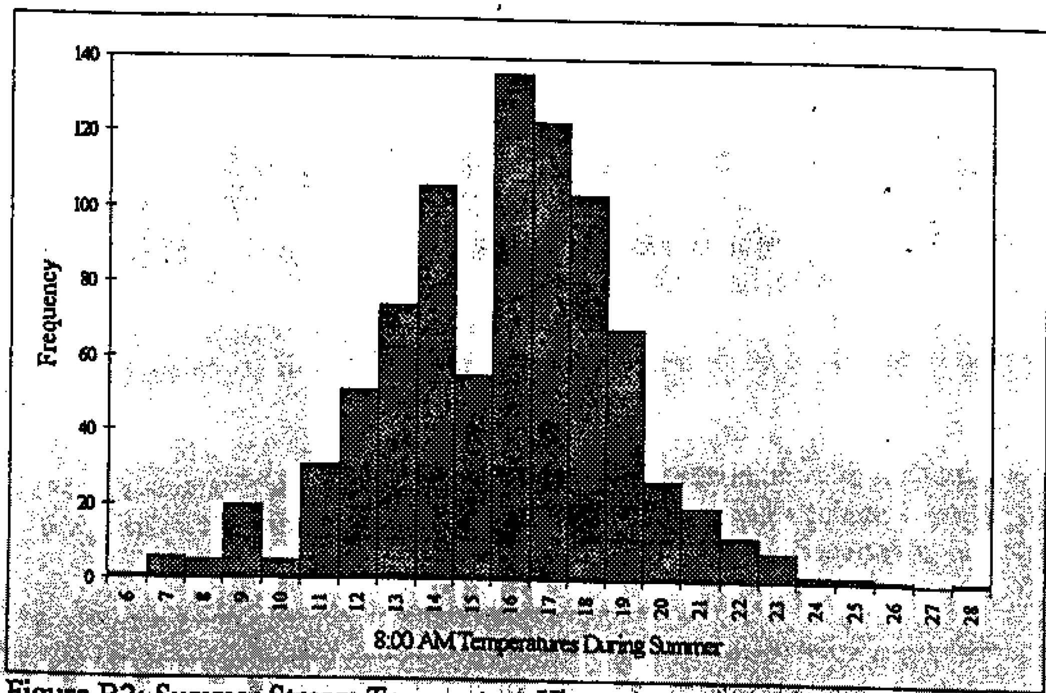


Figure B2: Summer Stream Temperature Histogram

Annual maximum 8:00 AM stream temperatures for the nineteen years of record were also examined (Figure B3). As the histogram in Figure B3 shows, the most frequent annual maximum temperature is also at 21 °C.

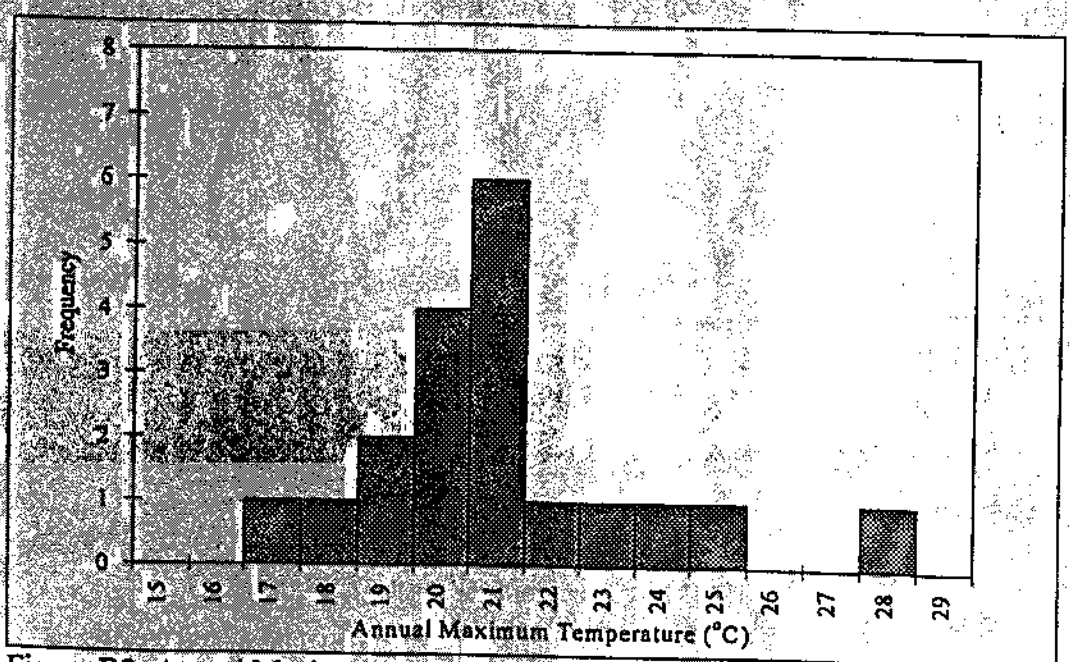


Figure B3: Annual Maximum 8:00 AM Stream Temperature Histogram

Assuming a normal distribution for these summer stream temperatures, the percentiles for high stream temperature occurrence were estimated (Table B1). Return periods of annual maximum 8:00 AM stream temperatures were also calculated (Table B2). The return period for an annual maximum 8:00 AM stream temperature of 21 °C is two years.

Table B1: Percentiles for 8:00 AM Stream Temperatures

Percentile (%)	Stream Temperature (°C)
80	18
90	20
95	21
97	22
99	23

Table B2: Return Periods for Annual Maximum 8:00 AM Stream Temperatures

Return Period (yr)	Stream Temperature (°C)
2	21
5	23
10	24
20	25
50	26

The current stream temperature was characterized by the 95th percentile for the 8:00 AM summer data, the most frequent annual maximum 8:00 AM stream temperature, and the 2 year return period temperature. This temperature, 21 °C, characterizes the current temperature loading regime for Paradise Creek upstream of the MWWTP at 8:00 AM. An additional increase of 2 °C was added to these 8:00 AM temperatures to approximate the daily maximum temperature. Rationale for this increase is discussed below.

Common Meteorologic Conditions During Temperature Exceedences

Energy enters the creek system and warms the creek through a variety of ways. Previous examinations of stream energy balances show four main energy sources: advective heat from incoming flow; net radiation; convective heat transfer from sensible heat, and latent heat loss of evaporation (Brown, 1969; Munn, 1966). Net radiation has been found to provide the greatest energy input and it is expected that an increase in shading will be proposed during the implementation phase of this TMDL. However, two additional factors also influence the energy input: (1) the residency time within the creek, which is a function of flow, and (2) the surface area/volume ratio, of width/depth ratio.

As can be seen in Figure B1, stream temperature exceedences occur during the summer, low flow periods of Paradise Creek. Common stream and meteorological conditions during these times of nonpoint related temperature exceedence include low flow and hot, sunny days. Figures B4 and B5 are included to describe the annual precipitation and air temperature patterns, and the annual stream flow and stream temperature patterns.

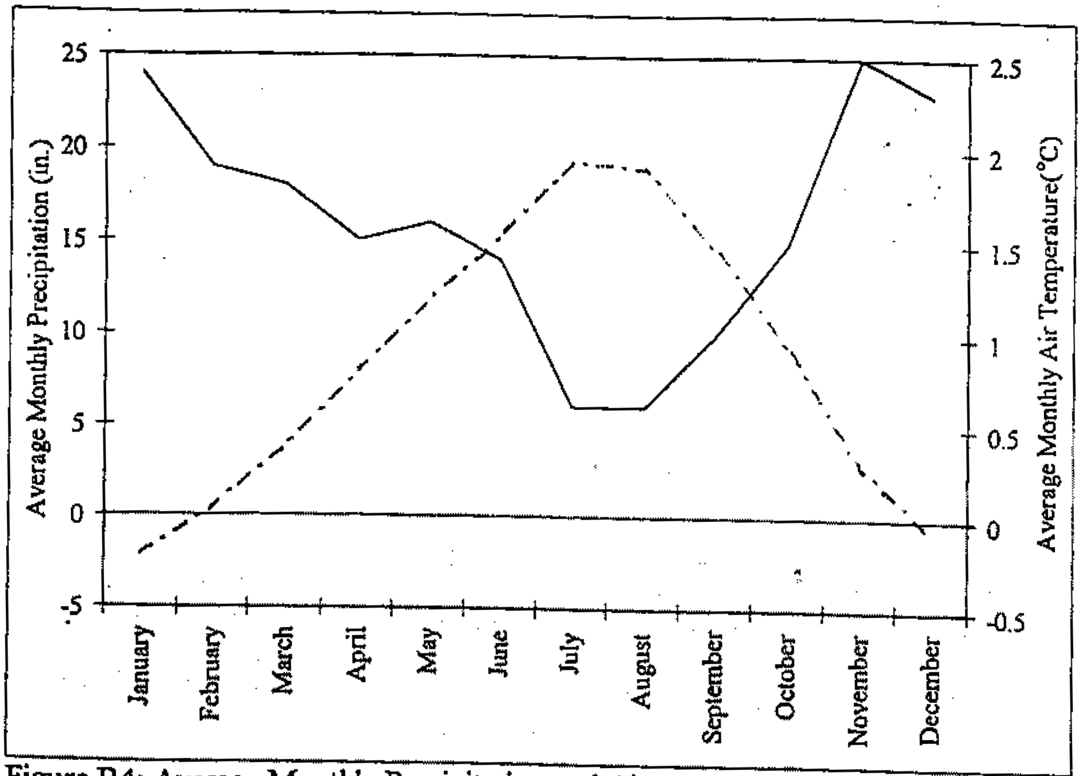


Figure B4: Average Monthly Precipitation and Air Temperature, Moscow Idaho

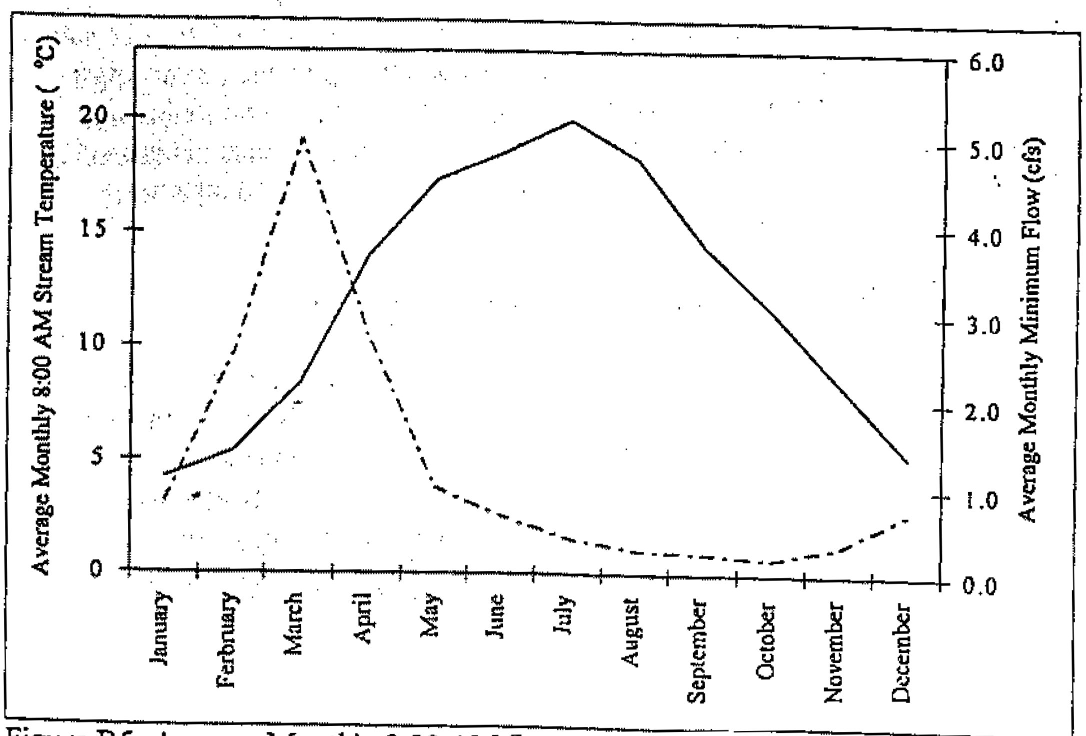


Figure B5: Average Monthly 8:00 AM Stream Temperature and Minimum Daily Flow Upstream of the MWWTP

The method commonly used to maintain cool stream temperatures is to limit the amount of solar energy to the stream, thus conserving the low temperature of groundwater inflow. In streams subject to waste water discharge impacts, the stream temperature may increase near the outfall, then decrease as energy is dissipated to the atmosphere (i.e. via evaporation and groundwater inflow cooling). However, a decrease in effluent temperature will occur only when the ambient air or stream temperature is less than the effluent temperature. Therefore, in order to meet the targets established at the state line, the temperature of water discharged to the stream must be at or below the target unless the ambient air temperature or the stream temperature is less that the target to provide cooling.

Relationship Between the 8:00 AM and the Daily Maximum Stream Temperature

Stream temperatures provided by the MWWTP were collected at 8:00 AM, three times a week, year round, over a nineteen year period (MWWTP, 1997). Locations for these morning temperatures include upstream of the MWWTP in Paradise Creek, downstream of the MWWTP in Paradise Creek, the inflow to the MWWTP, and the outflow from the MWWTP. These data represent instantaneous temperatures within the top six to twelve inches of the water column.

Continuous stream bottom temperatures were collected during a one month period in August, 1997 by the IDEQ in order to evaluate how the instantaneous morning data relate to daily average and daily maximum values, and to determine the temperature of the groundwater inflow into the creek system. Continuous temperature data sites included: below the MWWTP near the State line, a low elevation spring upstream of the City of Moscow, and a forested headwater stream segment located within the Nature Conservancy's Idlers Rest preserve. Table B3 shows how the surface MWWTP data compare with the IDEQ stream bottom data during the August, 1997 data period. A student's t-test comparing the mean of these two data sets showed no differences between them within a ninety-five percent confidence level.

Table B3. Eight AM Paradise Creek Stream Temperatures - August, 1997

Date	IDEQ Stream Bottom Temperature (°C)	MWWTP Stream Surface Temperature (°C)
8/8/97	18.5	18.3
8/11/97	17.7	16.7
8/13/97	18.8	18.3
8/15/97	19.0	18.9
8/18/97	18.5	17.8
8/20/97	18.5	18.9
8/22/97	18.0	17.2
8/25/97	17.5	18.3
8/27/97	18.6	18.9
8/29/97	16.7	18.3
9/1/97	18.3	17.8

Stream bottom temperatures recorded by the IDEQ at 8:00 AM were then compared with the daily variance about the mean, daily average, and daily maximum temperatures (Figures B6, B7, and B8). These comparisons show that the 8:00 AM temperature was always less than or the same as the maximum instantaneous temperature. Also, it is shown that as the 8:00 AM temperature increased the daily variance about the mean decreased (Figure B6). This indicates as the 8:00 AM temperatures increase, they become closer to the daily average and daily maximum temperatures (Figures B7 and B8).

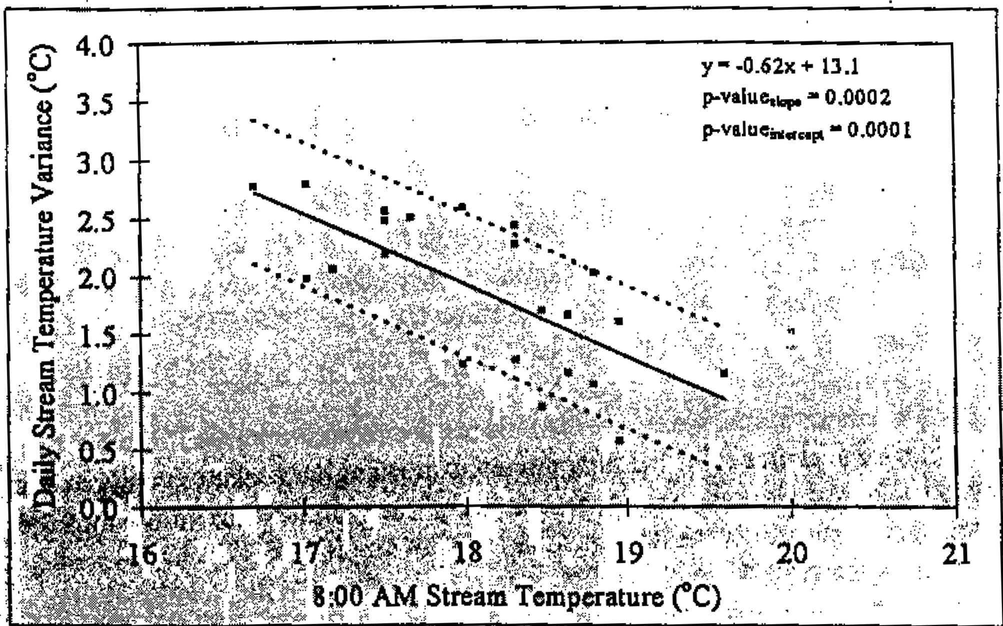


Figure B6: Regression Between the 8:00 AM and Daily Stream Temperature Variance with 90 Percent Confidence Interval

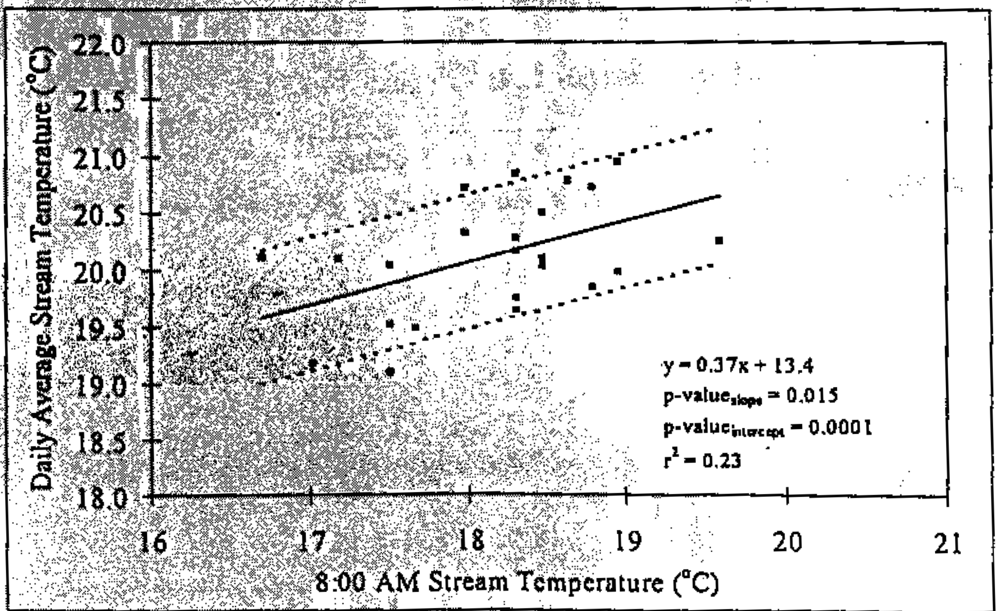


Figure B7: Regression Between the 8:00 AM and Daily Average Stream Temperature with 90 Percent Confidence Interval

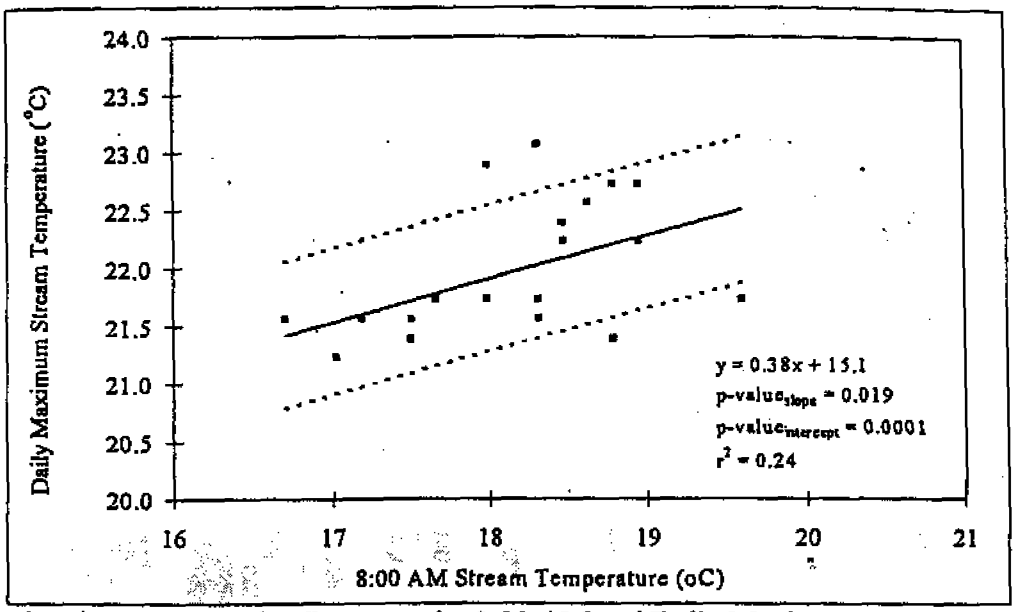


Figure B8: Regression Between the 8:00 AM and Daily Maximum Stream Temperature with 90 Percent Confidence Interval

It was originally thought that the 8:00 AM data might be able to predict the daily average and daily maximum stream temperatures. The predictions from these regressions are presented in Table B4. These show that as the 8:00 AM temperature increases, the daily average and the maximum temperature also increase.

Table B4: Predicted Stream Temperatures Using 8:00 AM Regression Equations

8:00 AM (°C)	Daily Average (°C)	Daily Maximum (°C)
16	19.3	21.2
17	19.7	21.5
18	20.1	21.9
19	20.4	22.3
20	20.8	22.7
21	21.2	23.0

Three problems with this analysis limited the application of these regressions: (1) the continuous data set in August, 1997 does not extend into the high stream temperatures range, (2) the r-squared value between the 8:00 temperature and the daily average is only 0.23, while the r-squared value between the 8:00 AM temperature and the daily maximum temperature is only 0.24, and (3) the 90 percent confidence interval bands around the relationships show around a 1 °C spread. Because of these concerns, the relationships derived between the 8:00 AM and the daily average and maximum temperatures are not used. It is made clear during this analysis, however, that those temperatures recorded at 8:00 AM are usually at or below the daily average and the daily maximum stream temperatures. Due to the limited data available for this analysis, the 8:00 AM temperatures are used to characterize the prevalent maximum stream temperatures over the period of record.

The uncertainty incurred by the use of the 8:00 AM temperature within this analysis is taken into account by applying a margin of safety of 2 °C to the current stream temperature. This two degree margin of safety is greater than the 90 percent confidence interval observed for the predicted daily maximum temperatures. This 2 °C MOS added to the current temperature of Paradise Creek of 21 °C provides a final temperature load estimate of 23 °C. Additional monitoring during implementation of this TMDL would be needed to determine how 8:00 AM temperatures relate to daily maximum temperatures.

Reduction of Stream Temperature Due to Non-Point Activities

Paradise Creek stream temperature load allocations were developed for nonpoint and point sources using a steady state, conservation of mass, and conservation of energy approach. The mathmatical relationships utilized in this approach begin with an energy balance for a small section of the creek. This small section is then integrated over the entire length. Assumptions inherent in this approach are that the system operates in a steady state and that the energy entering the system is independent of the energy state of the system. Both assumptions are considered reasonable due to previous work by Brown (1969).

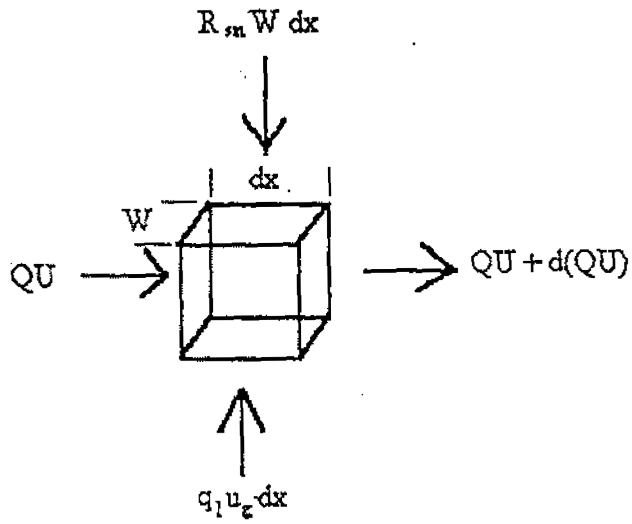


Figure B9. Portion of Creek Energy and Mass Balance Diagram

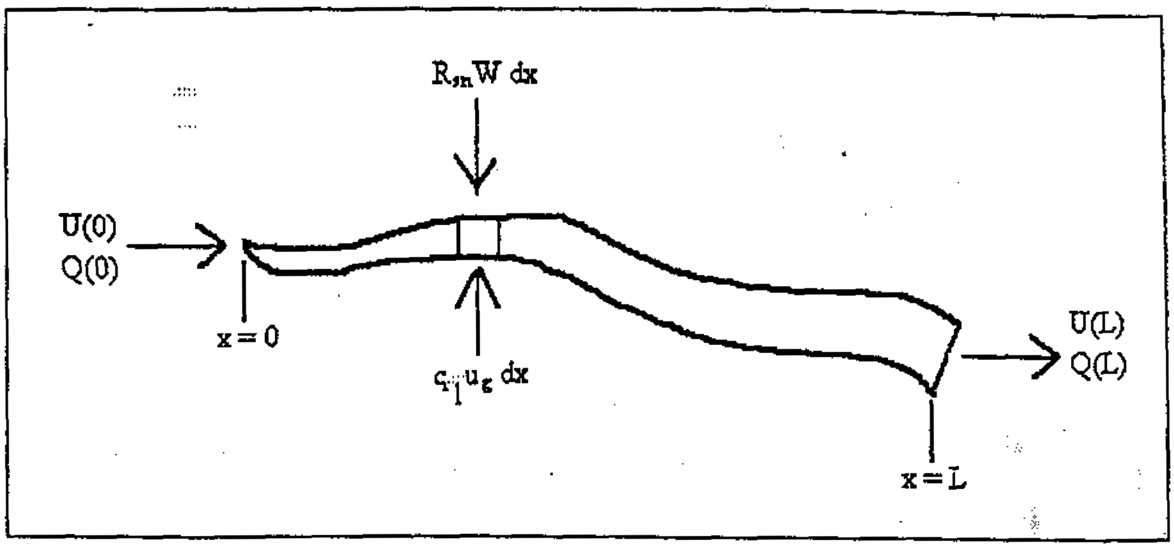


Figure B10. Creek Energy and Mass Balance Diagram

Applying conservation mass and energy as shown in Figures B9 and B10 to the creek system gives us:

$$R_{sn}Wdx + QU + q_lU_gdx - QU - d(QU) = 0 \tag{B1}$$

where:

R_{sn} = net solar radiation
W = stream width
Q = streamflow
U = stream energy
q_l = groundwater flow entering the creek (as a function of length)
U_g = groundwater energy entering the creek

Equation B1 can be re-written as:

$$R_{sn}Wdx + q_lU_gdx - d(QU) = 0 \tag{B2}$$

If we then integrate this relationship for the entire creek length (from x = 0 to x = L) we have:

$$\int_0^L R_{sn}Wdx + \int_0^L q_lU_gdx - \int_{Q(0)U(0)}^{Q(L)U(L)} d(QU) = 0 \tag{B3}$$

$$\int_0^L R_{sn}Wdx + q_lU_gL - Q(L)U(L) = 0 \tag{B4}$$

and, from mass balance,

$$q_lL = Q(L) \tag{B5}$$

Given that the groundwater inflow to that same small portion can be summed over the creek length for the total flow (B5), we have:

$$\int_0^L R_{sn} W dx + Q(U_g - U) = 0 \qquad \text{(B6)}$$

and:

$$\int_0^L R_{sn} W dx = Q(U - U_g) \qquad \text{(B7)}$$

Re-writing the energy terms as a function of temperature gives:

$$U = \rho_w C_s (T - T_{(U=0)}) \qquad \text{(B8)}$$

where:

ρ_w = density of water
C_s = specific heat of water
T = temperature
$T_{(U=0)}$ = datum temperature

Substituting Equations B8 into Equation B7 gives:

$$\int_0^L R_{sn} W dx = Q \rho_w C_s ((T - T_{(U=0)}) - (T_g - T_{(U=0)})) \qquad \text{(B9)}$$

Equation B9 can be re-written as:

$$\int_0^L R_{sn} W dx = Q \rho_w C_s (T - T_g) \qquad \text{(B10)}$$

and so we have the result of:

$$\frac{1}{Q \rho_w C_s} \int_0^L R_{sn} W dx = T - T_g \qquad \text{(B11)}$$

In summary, the difference between a selected stream temperature and the groundwater temperature is a function of the total flow of the system, the density of water, the specific heat of water, and the net solar radiation entering the creek system. This relationship allows the temperature differences between current and target stream temperatures to be translated into energy terms (i.e. kilo Joules). By writing these temperature differences in energy terms, the percent exceedence (Equation B12) and percent reduction required to meet the target temperature (Equation B13) are able to be determined.

$$\text{Precent Exceedence} = \frac{(T_{current} - T_g) - (T_{target} - T_g)}{(T_{target} - T_g)} \tag{B12}$$

$$\text{Precent Reduction} = \frac{(T_{current} - T_g) - (T_{target} - T_g)}{(T_{current} - T_g)} \tag{B13}$$

The groundwater temperature (T_g) was found to be about 11 °C during the month of August, 1997. Temperatures recorded by Lockwood (1996) at the top of the water column in shallow wells adjacent to Paradise Creek were found to range between 9 °C and 13 °C. Therefore, it was felt that the use of 11 °C was reasonable for the groundwater inflow temperature.

Inserting the groundwater inflow temperature (11 °C), the current temperature (23 °C), and target (18 °C) temperature into Equations B12 and B13 provides a percent exceedence in current energy input of 71% and a percent reduction of 42%.

Under scenarios where the estimated energy reductions required are greater than the predicted reductions due to shading, the reasonableness of the target temperature and an evaluation of other factors contributing to high stream temperature (i.e. flow and width:depth ratio) would be required. Additional temperature monitoring would need to evaluate canopy cover, residency time, and the width/depth ratio.

MWWTP Outflow Analysis

Stream temperature data provided by the MWWTP includes plant outflow temperature data. These outflow temperatures were recorded three times a week over a nineteen year period. The outflow temperatures were found to frequently exceed the target daily average temperature of 18 °C (Figure B11).

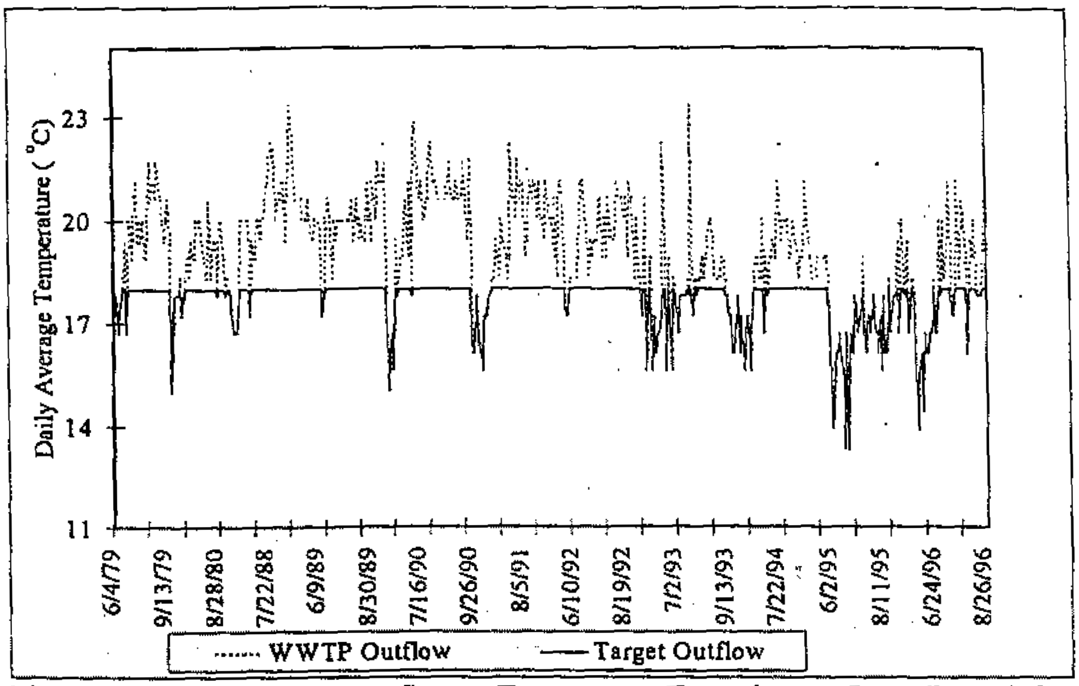


Figure B11: MWWTP Target Stream Temperature Exceedences, June Through September

Waste water from the MWWTP is discharged into Paradise Creek year round. The summertime outflow temperature from the MWWTP was determined by taking the average of temperatures recorded at 8:00 AM, three times a week, during the months of June - September for the period of record. The uncertain relationship between the 8:00 AM temperature and the maximum temperature was taken into account by applying a MOS of 2 °C to the resulting 8:00 AM stream temperature. The effluent temperature was found to average 19 °C during the summer months. With a 2 °C MOS, the current effluent temperature is estimated to be around 21 °C during this critical time of year.

However, the amount of warm waste water that can be discharged into the creek without exceeding the load capacity is a function of the actual temperature of the waste water Other factors that effect the amount of effluent able to be discharged into the creek so that the 18 °C load capacity is not exceeded are the temperature of the creek and the flow of the creek.

As in the case for nonpoint stream temperature targets, point source impacts to stream temperature are evaluated within a conservation of energy framework. Unlike the case for nonpoint analysis, however, differences in flow between the MWWTP outflow and Paradise Creek, as well as their respective temperatures, must be considered. Overall, the conductive temperature of the effluent becomes the dominant energy component and provides the greatest opportunity for energy input reduction.

The temperature for the stream segment downstream of the MWWTP can be shown to be a function of the MWWTP outflow amount and temperature, and the amount and temperature of the Paradise Creek flow using similar relationships and assumptions used for nonpoint stream temperature increases (Equations B1 - B11).

As discussed earlier, the daily maximum stream temperature load capacity is 18 °C, therefore, the maximum temperature of the discharge from the MWWTP must be 18 °C or less whenever the stream temperature in Paradise Creek is 18 °C or more. Equation B14 was utilized to calculate the allowable MWWTP outflow as a function of the identified instream conditions:

$$\text{Allowable Outflow} = \frac{Q_{stream}(T_{target} - T_{stream})}{T_{outflow} - T_{target}} \tag{B14}$$

The allowable rate of discharge for the MWWTP for a variety of Paradise Creek flows and temperatures are presented (Tables B5- B10). Figures B9 - B11 show the same relationship in a graphical format.

Table B5. Allowable MWWTP 19 °C Discharge*

Paradise Flow (cfs)	Paradise Temperature (°C)																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.5	9	8.5	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5	0
1	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0
3	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	0
4	72	68	64	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4	0
5	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
6	108	102	96	90	84	78	72	66	60	54	48	42	36	30	24	18	12	6	0
7	126	119	112	105	98	91	84	77	70	63	56	49	42	35	28	21	14	7	0
8	144	136	128	120	112	104	96	88	80	72	64	56	48	40	32	24	16	8	0
9	162	153	144	135	126	117	108	99	90	81	72	63	54	45	36	27	18	9	0
10	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0
15	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0
20	360	340	320	300	280	260	240	220	200	180	160	140	120	100	80	60	40	20	0
25	450	425	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0
30	540	510	480	450	420	390	360	330	300	270	240	210	180	150	120	90	60	30	0
40	720	680	640	600	560	520	480	440	400	360	320	280	240	200	160	120	80	40	0
50	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
100	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	0
150	2700	2550	2400	2250	2100	1950	1800	1650	1500	1350	1200	1050	900	750	600	450	300	150	0
200	3600	3400	3200	3000	2800	2600	2400	2200	2000	1800	1600	1400	1200	1000	800	600	400	200	0
250	4500	4250	4000	3750	3500	3250	3000	2750	2500	2250	2000	1750	1500	1250	1000	750	500	250	0
300	5400	5100	4800	4500	4200	3900	3600	3300	3000	2700	2400	2100	1800	1500	1200	900	600	300	0
400	7200	6800	6400	6000	5600	5200	4800	4400	4000	3600	3200	2800	2400	2000	1600	1200	800	400	0
800	14400	13600	12800	12000	11200	10400	9600	8800	8000	7200	6400	5600	4800	4000	3200	2400	1600	800	0

* 4.0 MGD = 6.2 cfs

Table B6. Allowable MWWTP 20 °C Discharge

Paradise Flow (cfs)	Paradise Temperature (°C)																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.5	4.5	4.3	4	3.8	3.5	3.3	3	2.8	2.5	2.3	2	1.8	1.5	1.3	1	0.8	0.5	0.3	0
1	9	8.5	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5	0
2	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
3	27	26	24	23	21	20	18	17	15	14	12	11	9	7.5	6	4.5	3	1.5	0
4	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0
5	45	43	40	38	35	33	30	28	25	23	20	18	15	13	10	7.5	5.0	2.5	0
6	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	0
7	63	60	56	53	49	46	42	39	35	32	28	25	21	18	14	11	7	3.5	0
8	72	68	64	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4	0
9	81	77	72	68	63	59	54	50	45	41	36	32	27	23	18	14	9	4.5	0
10	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
15	135	128	120	113	105	98	90	83	75	68	60	53	45	38	30	23	15	7.5	0
20	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0
30	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0
50	450	425	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0
100	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
150	1350	1275	1200	1125	1050	975	900	825	750	675	600	525	450	375	300	225	150	75	0
200	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	0
250	2250	2125	2000	1875	1750	1625	1500	1375	1250	1125	1000	875	750	625	500	375	250	125	0
300	2700	2550	2400	2250	2100	1950	1800	1650	1500	1350	1200	1050	900	750	600	450	300	150	0
400	3600	3400	3200	3000	2800	2600	2400	2200	2000	1800	1600	1400	1200	1000	800	600	400	200	0
800	7200	6800	6400	6000	5600	5200	4800	4400	4000	3600	3200	2800	2400	2000	1600	1200	800	400	0

Table B7. Allowable MWWTP 21 °C Discharge

Paradise Flow (cfs)	Paradise Temperature (°C)																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.5	3	2.8	3	2.5	2.3	2.2	2	1.8	1.7	1.5	1	1.2	1	0.8	1	0.5	0.3	0.2	0
1	6	5.7	5.3	5	4.7	4.3	4	3.7	3.3	3	2.7	2.3	2	1.7	1.3	1	0.7	0.3	0
2	12	11	11	10	9.3	8.7	8	7.3	6.7	6	5.3	4.7	4	3.3	2.7	2	1.3	0.7	0
3	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4	24	23	21	20	19	17	16	15	13	12	11	9.3	8	6.7	5.3	4	2.7	1.3	0
5	30	28	27	25	23	22	20	18	17	15	13	12	10	8.3	6.7	5	3.3	1.7	0
6	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0
7	42	40	37	35	33	30	28	26	23	21	19	16	14	12	9.3	7	4.7	2.3	0
8	48	45	43	40	37	35	32	29	27	24	21	19	16	13	11	8	5.3	2.7	0
9	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	0
10	60	57	53	50	47	43	40	37	33	30	27	23	20	17	13	10	6.7	3.3	0
15	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
20	120	113	107	100	93	87	80	73	67	60	53	47	40	33	27	20	13	7	0
30	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0
50	300	283	267	250	233	217	200	183	167	150	133	117	100	83	67	50	33	17	0
100	600	567	533	500	467	433	400	367	333	300	267	233	200	167	133	100	67	33	0
150	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
200	1200	1133	1067	1000	933	867	800	733	667	600	533	467	400	333	267	200	133	67	0
250	1500	1417	1333	1250	1167	1083	1000	917	833	750	667	583	500	417	333	250	167	83	0
300	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	0
400	2400	2267	2133	2000	1867	1733	1600	1467	1333	1200	1067	933	800	667	533	400	267	133	0
800	4800	4533	4267	4000	3733	3467	3200	2933	2667	2400	2133	1867	1600	1333	1067	800	533	267	0

Table B8. Allowable MWWTP 22 °C Discharge

Paradise Flow (cfs)	Paradise Temperature (°C)																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.5	2.3	2.1	2	1.9	1.8	1.6	1.5	1.4	1.3	1.1	1	0.9	0.8	0.6	0.5	0.4	0.3	0.1	0
1	4.5	4.3	4	3.8	3.5	3.3	3	2.8	2.5	2.3	2	1.8	1.5	1.3	1	0.8	0.5	0.3	0
2	9	8.5	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3.0	2.5	2	1.5	1	0.5	0
3	14	13	12	11	11	9.8	9	8.3	7.5	6.8	6	5.3	4.5	3.8	3	2.3	1.5	0.8	0
4	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5	23	21	20	19	18	16	15	14	13	11	10	8.8	7.5	6.3	5	3.8	2.5	1.3	0
6	27	26	24	23	21	20	18	17	15	14	12	11	9	7.5	6	4.5	3	1.5	0
7	32	30	28	26	25	23	21	19	18	16	14	12	11	8.8	7	5.3	3.5	1.8	0
8	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0
9	41	38	36	34	32	29	27	25	23	20	18	16	14	11	9	6.8	4.5	2.3	0
10	45	43	40	38	35	33	30	28	25	23	20	18	15	13	10	7.5	5	2.5	0
15	68	64	60	56	53	49	45	41	38	34	30	26	23	19	15	11	7.5	3.8	0
20	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
30	135	128	120	113	105	98	90	83	75	68	60	53	45	38	30	23	15	7.5	0
50	225	213	200	188	175	163	150	138	125	113	100	88	75	63	50	38	25	13	0
100	450	425	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0
150	675	638	600	563	525	488	450	413	375	338	300	263	225	188	150	113	75	38	0
200	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
250	1125	1063	1000	938	875	813	750	688	625	563	500	438	375	313	250	188	125	63	0
300	1350	1275	1200	1125	1050	975	900	825	750	675	600	525	450	375	300	225	150	75	0
400	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	0
800	3600	3400	3200	3000	2800	2600	2400	2200	2000	1800	1600	1400	1200	1000	800	600	400	200	0

Table B9. Allowable MWWTP 23 °C Discharge

Paradise Flow (cfs)	Paradise Temperature (°C)																	
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
0.5	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
1	3.6	3.4	3.2	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2	0
2	7.2	6.8	6.4	6	5.6	5.2	4.8	4.4	4	3.6	3.2	2.8	2.4	2	1.6	1.2	0.8	0.4	0
3	11	10	9.6	9	8.4	7.8	7.2	6.6	6	5.4	4.8	4.2	3.6	3	2.4	1.8	1.2	0.6	0
4	14	14	13	12	11	10	9.6	8.8	8	7.2	6.4	5.6	4.8	4	3.2	2.4	1.6	0.8	0
5	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
6	22	20	19	18	17	16	14	13	12	11	9.6	8.4	7.2	6	4.8	3.6	2.4	1.2	0
7	25	24	22	21	20	18	17	15	14	13	11	9.8	8.4	7	5.6	4.2	2.8	1.4	0
8	29	27	26	24	22	21	19	18	16	14	13	11	9.6	8	6.4	4.8	3.2	1.6	0
9	32	31	29	27	25	23	22	20	18	16	14	13	11	9	7.2	5.4	3.6	1.8	0
10	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0
15	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	0
20	72	68	64	60	56	52	48	44	40	36	32	28	24	20	16	12	8	4	0
30	108	102	96	90	84	78	72	66	60	54	48	42	36	30	24	18	12	6	0
50	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0
100	360	340	320	300	280	260	240	220	200	180	160	140	120	100	80	60	40	20	0
150	540	510	480	450	420	390	360	330	300	270	240	210	180	150	120	90	60	30	0
200	720	680	640	600	560	520	480	440	400	360	320	280	240	200	160	120	80	40	0
250	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
300	1080	1020	960	900	840	780	720	660	600	540	480	420	360	300	240	180	120	60	0
400	1440	1360	1280	1200	1120	1040	960	880	800	720	640	560	480	400	320	240	160	80	0
800	2880	2720	2560	2400	2240	2080	1920	1760	1600	1440	1280	1120	960	800	640	480	320	160	0

Table B10. Allowable MWWTP 24 °C Discharge

Paradise Flow (cfs)	Paradise Temperature (°C)																		
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
0.5	1.5	1.4	1.3	1.3	1.2	1.1	1	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.1	0
1	3	2.8	2.7	2.5	2.3	2.2	2	1.8	1.7	1.5	1.3	1.2	1	0.8	0.7	0.5	0.3	0.2	0
2	6	5.7	5.3	5	4.7	4.3	4	3.7	3.3	3	2.7	2.3	2	1.7	1.3	1	0.7	0.3	0
3	9	9	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5	0
4	12	11	11	10	9	9	8	7.3	6.7	6	5.3	4.7	4	3.3	2.7	2	1.3	0.7	0
5	15	14	13	13	12	11	10	9.2	8.3	7.5	6.7	5.8	5	4.2	3.3	2.5	1.7	0.8	0
6	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
7	21	20	19	18	16	15	14	13	12	11	9	8.2	7	5.8	4.7	3.5	2.3	1.2	0
8	24	23	21	20	19	17	16	15	13	12	11	9	8	6.7	5.3	4	2.7	1.3	0
9	27	26	24	23	21	20	18	17	15	14	12	11	9	7.5	6	4.5	3	1.5	0
10	30	28	27	25	23	22	20	18	17	15	13	12	10	8.3	6.7	5	3.3	1.7	0
15	45	43	40	38	35	33	30	28	25	23	20	18	15	13	10	7.5	5	2.5	0
20	60	57	53	50	47	43	40	37	33	30	27	23	20	17	13	10	6.7	3.3	0
30	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
50	150	142	133	125	117	108	100	92	83	75	67	58	50	42	33	25	17	8	0
100	300	283	267	250	233	217	200	183	167	150	133	117	100	83	67	50	33	17	0
150	450	425	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0
200	600	567	533	500	467	433	400	367	333	300	267	233	200	167	133	100	67	33	0
250	750	708	667	625	583	542	500	458	417	375	333	292	250	208	167	125	83	42	0
300	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100	50	0
400	1200	1133	1067	1000	933	867	800	733	667	600	533	467	400	333	267	200	133	67	0
800	2400	2267	2133	2000	1867	1733	1600	1467	1333	1200	1067	933	800	667	533	400	267	133	0

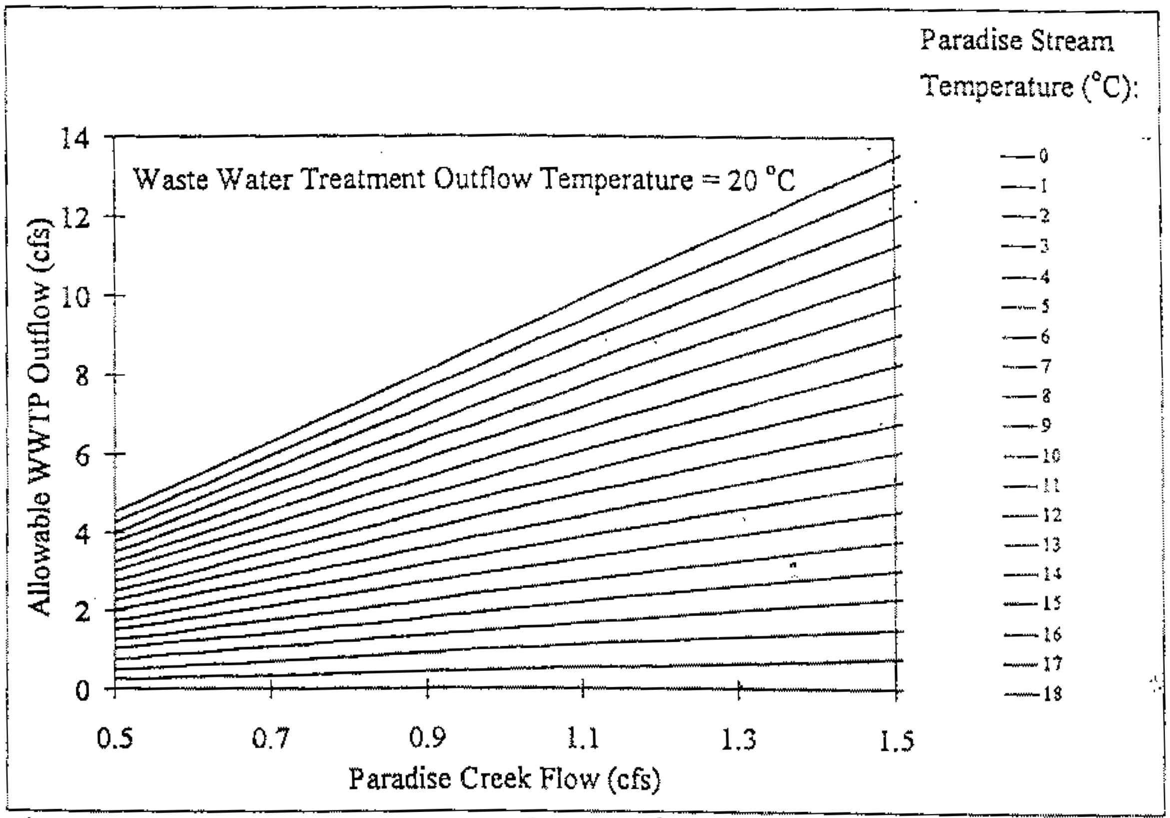


Figure B8. Allowable Waste Water Outflow at 20 °C

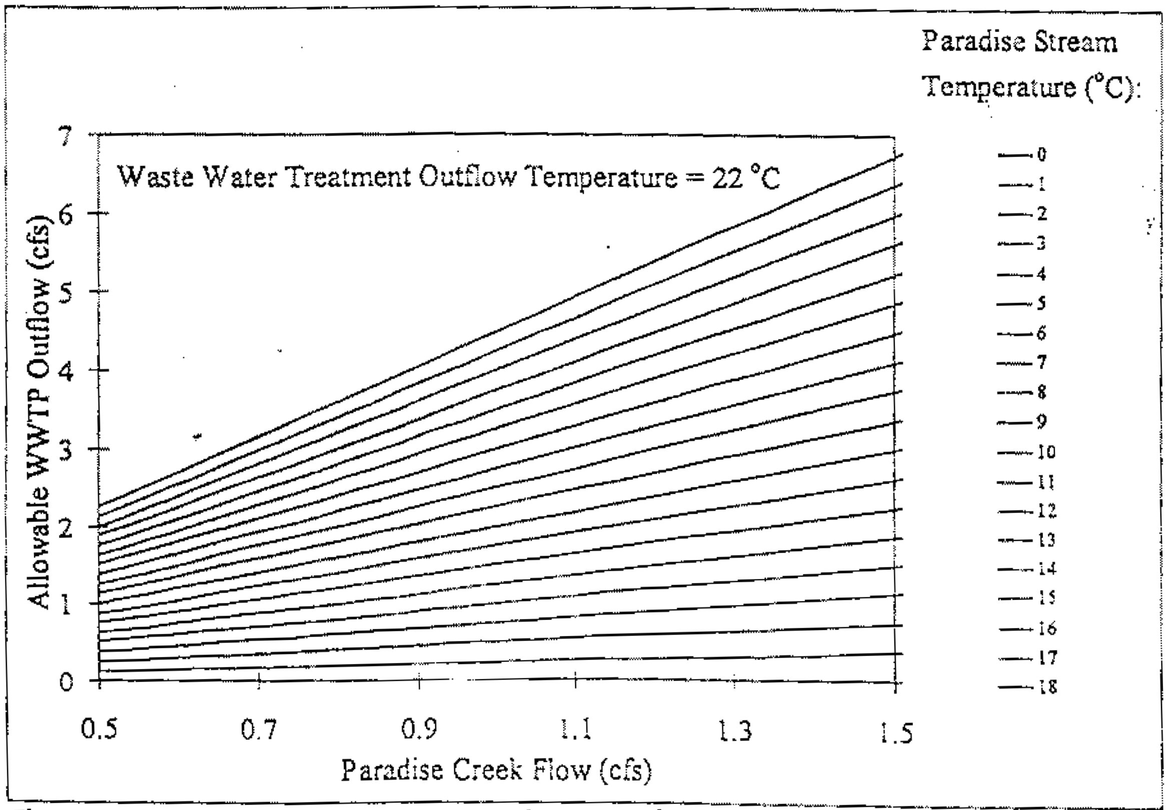


Figure B9. Allowable Waste Water Outflow at 22 °C

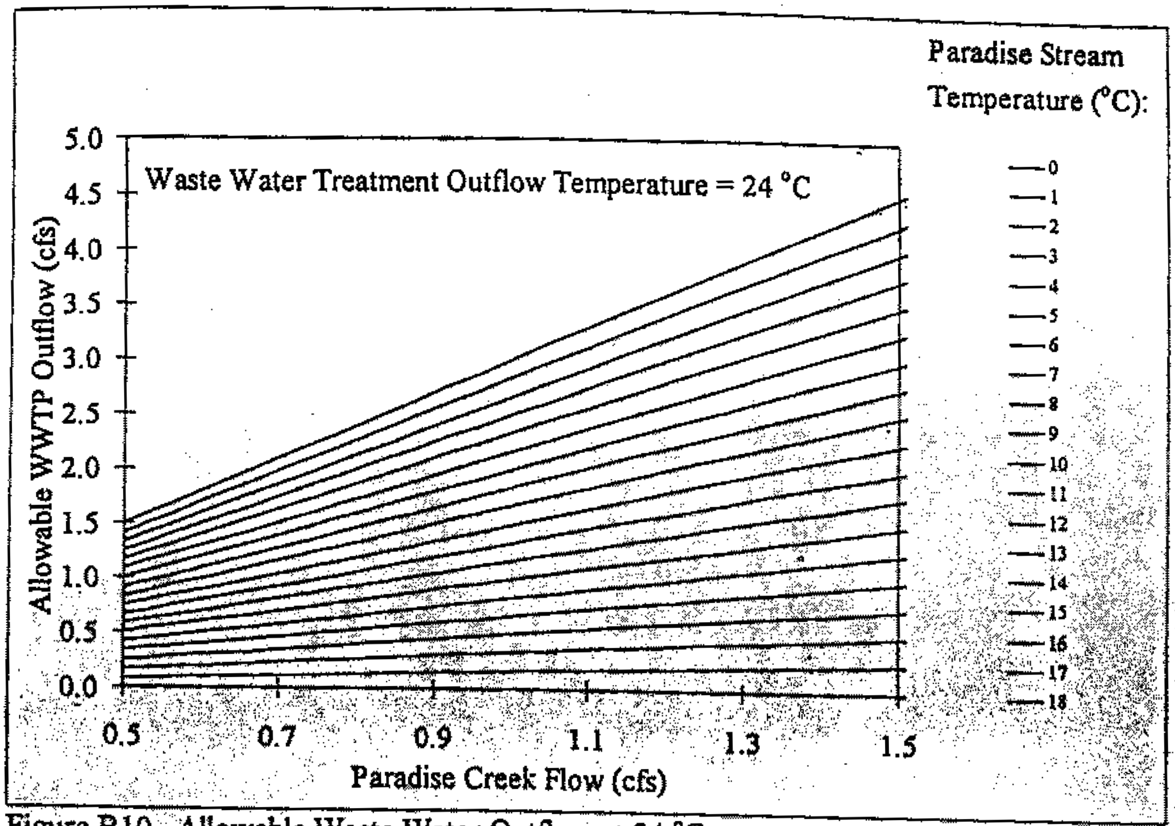


Figure B10. Allowable Waste Water Outflow at 24 °C

State water quality standards that pertain to point source operations have additional stipulations for the mixing of waste water discharge. For example, unless specific exemptions are made, "the temperature of the wastewater must not affect the receiving water outside the mixing zone so that: (1) the temperature of the receiving water or of downstream waters will interfere with designated beneficial uses, (ii) daily and seasonal temperature cycle characteristics of the water body are not maintained, ... (iv) if the water is designated for cold water biota or salmonid spawning, the induced variation is more than plus one (+1) degree C" (IDAPA 16.01.02.401.03.a).

Also, current mixing zone policy states that if a designated mixing zone exists in a flowing receiving water, the Department will consider the principle that "the mixing zone is not to include more than twenty-five percent (25%) of the volume of the stream" (IDAPA 16.01.02.060.01.e.iv). Neither a greater than 1 °C increase to stream temperature during cooler seasons of the year or a greater than twenty-five percent proportion of MWWTP discharge are considered in the load capacity calculations for Paradise Creek. These and other considerations specific to the MWWTP point source discharge will need to be determined by the local IDEQ permitting engineer during 401 permit certification.

APPENDIX C

PARADISE CREEK URBAN LOAD ESTIMATES

APPENDIX C-PARADISE CREEK URBAN LOAD ESTIMATES

Limnotech, Inc. in the Demonstration TMDL for Paradise Creek (1993) estimated urban loading for the Paradise Creek watershed. In this exercise, three other methods were used to calculate urban load estimates. After examination of results, urban load estimates recommended for TMDL use are: TP = 1758 lbs/yr; TSS = 185 tons/yr.

Introduction

According to Novotny and Olem (1994), nonpoint source pollution in urban areas is quite different from that in rural lands. Several factors cause the difference (Novotney and Chester, 1981) including:

1) Large portions of urban areas are impervious resulting in much higher hydrologic activity.
2) Hydrologic response to precipitation is faster
3) Most pervious land surfaces, except construction sites, are protected by lawns and other vegetation; consequently erosion is reduced relative to rural lands.

Runoff from urban watersheds originates from both pervious and impervious surfaces. The impervious surfaces are almost always hydrologically active because their depression storage represents only a small subtraction from rainfall. Thus the amount of pollutants washed off by rainfall from impervious surfaces depends on the amount of pollutants that has accumulated during the preceding dry period and on the energy of the runoff. On the other hand, the hydrological subtraction from rainfall on pervious surfaces (soils) is much larger, and usually only some storm events will yield appreciable runoff and sediment load.

Limnotech, Inc. in the Demonstration TMDL for Paradise Creek (1993) estimates urban loading from the Moscow and University of Idaho at 1.14 kg/day TP and 990 kg/day TSS. The estimates for urban loading at the Idaho-Washington state line are:

TP 918 lb/yr
TSS 398 tons/yr

Limnotech performed loading estimates by programing ARCINFO to automatically divide the Idaho portion of the Paradise Creek watershed into discrete homogenous source areas and loaded the stored results into a spreadsheet. The spreadsheet determined if land use was urban or rural and applied the appropriate model equation. The equations Limnotech used are described in EPA (1985) and previously proposed by Heany and Huber (1979). A more detailed explanation is provided in the methods section of this appendix.

Several other methods were used to estimate urban loading for TSS and TP for comparison with Limnotech's results. The methods and results are summarized below.

Calculated Estimates Using NURP Data (Novotny and Olem, 1994)

A statistical analysis of data collected during the pilot studies of the Nationwide Urban Runoff Program (NURP), sponsored by the U.S. Environmental Protection Agency (1983), found no significant statistical differences between the mean concentrations of pollutants in urban runoff among the typical urban land uses. *The NURP study of the quality of urban runoff was unable to statistically identify a nationwide effect of any systematic factors on the unit loads except imperviousness, which effects the runoff volume and, consequently, the unit loads.* The NURP research provided a large database on the quality and loads by urban runoff. NURP studies focused on evaluating the event mean concentrations (EMC), defined as:

EMC=Mass of pollutant contained in the runoff event/total volume of flow in the event.

NURP found the EMC parameter to be the most appropriate variable for evaluating the impact of urban runoff. The study established that event mean concentrations for total suspended solids (TSS), total phosphorus, total Kjeldahl nitrogen are extremely well represented by the log-normal distribution. The nationwide analysis did not find significant statistical correlations of the EMCs to the geographical locations of the site and concluded if land use category effects are present, they are eclipsed by storm to storm variability; therefore, land use category is of little general use in predicting urban runoff quality at unmonitored sites or in explaining site to site differences where monitoring data exists. The NURP study also concluded that there is no significant correlation between EMCs and runoff volume. *In deterministic concepts, factors such as slope, soil types, and rainfall characteristics are all potentially important. However, in a statistical sense derived from a large number of observations at various sites throughout the United States, these factors did not appear to have any real significance in explaining observed similarities or differences among individual sites.* A detailed discussion of the statistical methods used in the NURP study, conclusions reached, and comparison of NURP results to deterministic model findings is found in Novotny and Olem (1994), pp.484-495.

Urban loading to Paradise Creek was calculated using midrange NURP EMC mean values of pollutant load estimates for median urban sites. The procedure used is outlined in Novotny and Olem (1994). Percent imperviousness was determined by tabulation of various land uses, application of a imperviousness value for each land use and calculation of total impervious acres in the urban area divided by total area. Imperviousness values applied to each land use were estimated from discussions with the Moscow City Planner, direct observation, EPA published estimates, and values obtained from the City of Boise storm water study. When in doubt, the most conservative (highest) estimate of imperviousness was used. Acreage of land uses were obtained from the city of Moscow planning department (Plaskon, pers. comm.) and University of Idaho Capitol Planning (Ferrin, pers.comm.). Runoff coefficient was taken from figure 8.2 in Novotny and Olem (1994). Data is listed in Table C1. Calculations and results are shown in figure 1. Using this method, median annual loadings from Moscow and the University of Idaho to Paradise Creek are:

TP	3390 lb/yr
TSS	740 tons/yr

Boise City/Ada County Storm water Model ("Simple Method")

TSS and Total Phosphorus loading for Idaho's urban portion of the Paradise Creek watershed was also computed using a spreadsheet model designed to estimate municipal nonpoint source loads to the lower Boise River. The procedure is outlined in the methods section and results are tabulated in Table C2. Using this method annual average urban pollutant loading to Paradise Creek is estimated as:

TP = 1,758 lbs/yr
TSS = 185 tons/yr

PLUARG

Marsalek (1978) compiled data measured by PLUARG (Pollution by Land Use Activities-Reference Group) of the International Joint Commission and other estimates and related them to four land-use categories. The unit loads presented by Marsalek (table 8.2 in Novotny and Olem, 1994) correlated to respective urban land use types within the Paradise Creek watershed result in annual load estimates of 4388 lbs/yr TP and 510 tons/ year. This was the crudest estimation method used. Data is presented in Table C3.

Methods Used

Urban Loading Functions (Limnotech, Inc., 1993)

EPA (1985) describes a general urban loading function proposed by Heany and Huber (1979) of the form

$$L_k = \alpha_k F_k P$$

where

L_k = annual load of pollutant due to runoff from land use k (kg/ha/year)
α_k = pollutant concentration factor (kg/ha-cm)
F_k = population density function

Total pollutant load from urban areas is determined as:

$$L = \sum L_k A_k$$

where

L = annual pollutant load (kg/yr)
L_k = annual load of pollutant due to runoff from land use k (kg/ha/year)
A_k = area of land use k (ha)

Pollutant concentration factors were taken from Heaney and Huber (1979), and averaged over the categories or residential and commercial to represent urban lands in the watershed.

The population density factor for urban areas is:

$$F_k = 0.142 + 0.134\ PD^{0.54}, \text{ for residential}$$
$$= 1.0 \qquad\qquad , \text{ for commercial}$$

where

PD = Population density (persons/ha)

Population density in Moscow was taken as 25.8 based on the population density of Moscow from the 1990 census multiplied by the Moscow urban area within the Paradise Creek drainage basin plus 1992 University of Idaho enrollment. These result in a value for F_k of 0.916 for Moscow. Annual precipitation for the Moscow area was taken from local climatological data to be 60.96 cm/year.

Urban Storm water Loading Estimates Based on NURP EMC Data
(after Novotny and Olem, 1994)

Given:

Total Area: 1767 ha (4366 acres)
Land Use: Urban
Annual Precipitation: 61 cm (24 inches)
Percent Imperviousness: 42% (Table C1)
Coefficient of Runoff: 0.34 (Table 8.2, Novotny and Olem, 1994)

For estimating nonpoint source loads from urban sites, the average of the range for event mean concentrations (EMCs) was taken for the pollutants of interest (Table 8.15, Novotny and Olem, 1994). These values are:

TP = 0.42 mg/l
TSS = 183 mg/l

Total P_{mean} = CR*precipitation volume*EMC

Total P_{mean} = 0.34 * 61 (cm) * 0.01 (cm/m) * 10,000 (m^2/ha) * 0.42 (g/m^3) *0.001 (kg/g)

Total P_{mean} = 0.87 kg/ha per year

Annual Total Phosphorus Load = 1767 ha * 0.87 kg/ha = 1537 kg = 3390 lbs

Using this method of calculation,

TSS_{mean} = 0.34 * 61 (cm) * 0.01 (cm/m) * 10,000 (m^2/ha) * 183 (g/m^3) *0.001 (kg/g)

TSS_{mean} = 380 kg/ha per year

Annual Total Suspended Solids Load = 1767 ha * 380 kg/ha = 671,460 kg
=1,480,482 lbs = 740 tons

Boise City/Ada County Storm water Comprehensive Plan Model (Ada County Highway District and others, 1997)

Pollutant loading was also calculated using a "simple" method derived from 1992 EPA guidance for developing Part II Applications for NPDES municipal storm water discharge permits and used to estimate pollutants loads from nonpoint sources in and around developing watersheds in the Boise River watershed. Documentation is taken from chapter 4 of the Boise City/Ada County Storm water Comprehensive Plan (Part II Permit Application). Results are presented in Table C2.

Using this method, the average annual pollutant load from storm water is computed by multiplying the runoff volume by a mean pollutant concentration. The generic equation is:

$$L_{ijk} = V_{ij} \times C_{ik} \times [6.245 \times 10^{-5}\ \mathit{lb\text{-}l/mg\text{-}ft^3}] \quad \text{Equation 1}$$

where:

C_{ik} = the estimated mean concentration of pollutant k for land use I, in units of milligrams per liter (mg/L)

V_{ij} = the estimated storm water runoff volume from land use I, within drainage basin j, in units of cubic feet per year (ft^3/year)

L_{ijk} = the calculated average annual load of pollutant k for land use I, within drainage basin j, in units of pounds per year (lbs/yr)

Computation of pollutant loads is repeated for each pollutant of concern.

The annual runoff volume is computed as the product of the drainage area, runoff coefficient, and annual precipitation. EPA's method applies a correction factor to the annual precipitation to adjust for storms where no runoff occurs. The equation for average annual storm water runoff volume is expressed as the following:

$$V_{ij} = [3{,}630\ \mathit{ft^3/in\text{-}ac}] \times P \times CF \times Rv_i \times A_{ij} \quad \text{Equation 2}$$

where:

P = the average annual precipitation in units of inches per year (in/yr)

CF= correction factor that adjusts for the amount of average annual rainfall which is available for runoff

Rv_i= the runoff coefficient for land use I (dimensionless)

A_{ij} = the acreage of land use I within drainage basin j

V_{ij} = the calculated average annual storm runoff volume from land use I within drainage basin j, in units of cubic feet per year (ft^3/year)

3,630 = conversion factor for in-ac to ft^3

To compute the cumulative loads from a drainage basin, the loads for all land uses within the basin (from Equation 1) are summed. Mathematically this relationship is expressed by the following equation:

$$L_{jk} = {}^{n}\sum_{I} L_{ijk} = {}^{n}\sum_{I} (6.245 \times 10^{-5}) \times V_{ij} \times C_{ik} \quad \text{Equation 3}$$

where:

L_{jk} = the calculated average annual load of pollutant k for drainage basin j, in units of pounds per year (lbs/yr)

$\sum_{I}$ = summations over all land uses I

n = number of land uses

The average concentration of a pollutant from a particular drainage basin can be computed by dividing the cumulative pollutant load by the runoff volume. The equation for the average pollutant concentration from a drainage basin is:

$$C_{jk} = L_{jk} / [\sum_{j}\sum_{I} (6.245 \times 10^{-5}) \times V_{ijk}] \qquad \text{Equation 4}$$

Using the equations presented above, loads can be summed for all land uses in drainage basins to obtain overall pollutant loads and average concentrations for use in TMDL development.

Results for the urban portion of the Idaho side of the Paradise Creek watershed are presented in Table C2.

The following data are needed to use the methodology outlined above:

- Land use acreage A_{ij} for each land use type I, within drainage basin j
- The annual precipitation P
- The runoff coefficient Rv_{I} for each land use I

The storm water runoff volumes V_{ij} from land use I within drainage basin j are computed from the land use acreage, runoff coefficients, and annual precipitation using Equation 2. These are then combined with the pollutant concentrations C_{jk} to compute pollutant loads as given in Equation 1.

Land use data and acreage breakdowns were obtained from the Moscow Planning Department (J.Plaskon, pers. comm.) and the University of Idaho Capital Planning (S.Ferrin, pers. comm.). Annual average rainfall input (24 inches) was obtained from Doke and Hashmi (1994).

The runoff coefficient, or ratio of runoff to rainfall, is used to convert rainfall data to estimates of runoff volume. Prior studies (EPA 1983; FHWA 1987) which developed and analyzed rainfall-runoff characteristics using very large databases for both urban areas and highways, have indicated that the runoff volume (and hence, the runoff coefficient) is strongly related to the fraction of impervious surface area within a predominantly urban watershed. Impervious areas are those portions of a drainage basin where infiltration of rainfall cannot take place and surface runoff occurs. The relationship used in this analysis to convert rainfall to subsequent runoff (the runoff coefficient) is based on the equation given in the EPA guidance document (EPA, 1992):

$$Rv_i = 0.05 + 0.009 \times IMP_i \qquad \text{Equation 5}$$

where:

Rv_i =runoff coefficient for land use *I*, expressed as a fraction

IMP_i=impervious area for land use *I*, expressed as a percentage

For the Paradise Creek watershed, the percentage of impervious area for a given land use category was based on discussions with the Moscow City Planner, direct observation, EPA published estimates, and values obtained from the City of Boise storm water study. When in doubt, the most conservative (highest) estimate of imperviousness was used.

The fraction of average annual precipitation available for runoff (26%) was obtained from Hankley (pers. comm.) based on a 1968 USDA-ARS publication reporting 1935-1937 data (ref?). Other annual runoff percentage estimates were obtained from McCool (17%) and Pankuk (10-29%). The 26% runoff number appears conservative, is based on 3 years data, and was chosen as the model input.

Pollutant Concentrations

Estimates of annual pollutant loads require an estimation of the mean concentration of each parameter for each land use category. Storm water quality data for an individual storm event is reported as an event mean concentration (EMC) of a particular pollutant. This EMC is the concentration of a sample that was collected as a flow-composite throughout the duration of a storm event. The EMC is therefore defined as the total mass discharge of that pollutant divided by the total runoff volume for the storm event

When multiple storm events are monitored at a station, the EMCs observed are usually quite variable. The central tendency can be defined as the median of the EMCs. It is generally accepted that storm water quality data are well characterized by a log-normal probability distribution (EPA, 1983; FHWA, 1989). The median EMC is calculated by combining all the EMCs obtained from multiple storm events at a site and finding the 50th percentile value (based on a log-normal distribution). This median EMC is designated as the site median concentration (SMC). The SMC can then be compared with SMCs measured during the NURP (EPA, 1983). The variability in the concentrations from different events may be defined by the coefficient of variation (COV) parameter, which equals the standard deviation divided by the mean of the EMCs.

When the data are log-normally distributed, the following procedure can be utilized to estimate population statistics. To obtain the estimate of the population mean concentration (μ), SMC and COV, the data are transformed to logarithmic scale. The average (μ_y) and standard deviation (σ_y) of the transformed data are computed.

For Paradise Creek, EMCs were obtained from SMCs developed for the Boise Storm Water Comprehensive Plan and applied to equivalent land uses within the Paradise Creek watershed. Local storm water quality data is insufficient for a more site-specific analysis.

Recommended Urban Load Estimates for TMDL Use

It is recommended pollutant load estimates calculated using the "simple" method outlined in the Boise City/Ada County Storm Water Comprehensive Plan be used for Paradise Creek. Event Mean Concentrations used in this method are more regional than NURP data and were partially developed by monitoring programs in Idaho; other values used were based on data collected in Oregon and California urban areas. Loadings derived from this model show reasonable agreement with those calculated using NURP data. Loading ratios are +1.2 for TSS and -2.0 for TP between the two methods.

Chandler (1994) reviewed case studies that used either SWMM or HSPF to estimate annual urban storm water runoff volumes and pollutant loads. These estimates were then compared to estimates made using the "simple" method; 124 comparisons were made. Seventy percent of the maximum ratio values ranged from 1 to 2, indicating that, in general, the computer model and "simple" method results were comparable. Chandler's study suggests that the "simple" method , with some refinements of the "EMC" values for current, local conditions and recognition of the method's limitations, is a useful tool that can provide reasonable pollutant load estimates quickly and cheaply.

A margin of safety (MOS) is provided by using very conservative values for land use imperviousness and conservative average annual values for runoff. *Expand this discussion.*

Recommended urban loading estimates for Paradise Creek TMDL use are:

TP = 1758 lbs/yr
TSS = 185 tons/yr

References Cited

Ada County Highway District and Other Co-applicants, 1997. Draft NPDES Municipal Storm Water Permit Application. Prepared by Woodward-Clyde Consultants.

Chandler, R.D., 1994. Estimating annual urban nonpoint pollutant loads. Journal of Management in Engineering 10(6): 50-59

Doke, J.L. and Hashmi, G.S., 1994. Paradise Creek Watershed Characterization Study, State of Washington Water Research Center, 131 pp.

Ferrin, S., 1997. University of Idaho Capitol Planning. Personal communication.

Hankley, D., 1997. Idaho Soil Conservation Commission. Personal communication.

Heany, J.P. and Huber, W.C., 1979. Nationwide cost of wet-weather pollution control. Journal of the Water Pollution Control Federation 51(8): 2043-2053

Limnotech Inc., 1993. Paradise Creek Demonstration TMDL report.

Marsalek, J. 1978. Pollution due to urban runoff: unit loads and abatement measures, Pollution from Land Use Activities Reference Group, International Joint Commission, Windsor, Ontario.

McCool, D., 1997. USDA Agricultural Research Service, Pullman, WA. Personal communication.

Novotny, V. and O.em, H., 1994. Water Quality: prevention, identification, and management of diffuse pollution. Van Nostrand Reinhold, New York, 1054 pp.

Pankuk, C., 1997. USDA Agricultural Research Service, Pullman, WA. Personal communication.

Plaskon, J., 1997. City of Moscow Planning. Personal communication.

U.S. EPA, 1983. Results of the nationwide urban runoff program. Vol. 1-final report. Water Planning Division. NTIS PB84-18552. Washington, DC.

U.S. EPA, 1985. Water quality assessment: a screening procedure for toxic and conventional pollutants in surface and groundwater-part 1.

U.S. EPA, 1992. Guidance Manual for Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems. EPA 833-B-92-002. Washington, D.C.

PARADISE CREEK TMDL
RESPONSE TO PUBLIC COMMENT

The Paradise Creek Draft TMDL was made available for public comment from November 5, 1997 through December 5, 1997. The Draft also was made available for public comment at the November 20, 1997 Paradise Creek Watershed Advisory Group public meeting and the December 4, 1997 Clearwater Basin Advisory Group public meeting.

Comments were received from:

Environmental Protection Agency
Inland Empire Public Lands Council
Natural Resource Conservation Service
Latah Soil Water Conservation District
Resource Planning Unlimited
Nez Perce Tribe
Petition Signed by 38 Individual Citizens
Paradise Creek Watershed Advisory Group
Idaho Department of Lands
Idaho Association of Soil Conservation Districts
City of Moscow
University of Idaho
Palouse Clearwater Environmental Institute

The following comments were received during the public comment period. The comments have been organized and compiled into specific themes to reduce duplication of comments. The comments listed may not be verbatim. Comments may be revised to reflect a common theme. Each comment is followed by a response, including how the comment has been incorporated into the Paradise Creek TMDL. The petitions submitted focused on the City of Moscow's efforts to address urban flooding issues. The petitions did not focus on the Paradise Creek TMDL.

Comment — The document needs to further clarify the application of state water quality standards, in stream targets and point source permit limitations.

Response — State water quality standards have been clearly defined in a separate section of the document, in stream targets and permit limitations have been clearly identified and explained for each pollutant.

Comment — Discussion of the state's mixing zone policy needs to be consolidated in a single section, concluding with a statement that the Moscow Waste Water Treatment Plant does not qualify for a mixing zone and all discharge limits are applied to the end of the outfall.

Response — This has been addressed in the State Water Quality Standards section.

Comment — The heat budget equation used in the temperature analysis should be provided and demonstrate how the load capacity and allocations were developed.

Response — This has been addressed in Appendix B.

Comment — The TMDL should provide an analysis that links increased shading with energy

	reductions.
Response	Published references correlating canopy cover and shading with decreased water temperatures are available. Specific implementation actions for increasing shading and canopy cover will be listed in the Paradise Creek TMDL implementation plan.
Comment	Stream classification mapping and riparian condition surveys should be listed as required future monitoring under a phased TMDL.
Response	This is discussed in the TMDL's additional information and data gaps section. Specifics of the monitoring plan maybe developed further in the Paradise Creek implementation plan.
Comment	Assumptions made need to be clearly stated and justified.
Response	This has been done within the text of the document and appendices where appropriate.
Comment	Washington State's water quality temperature standards is instantaneous not maximum daily average.
Response	This has been addressed in the Water Quality Standards section and in the temperature analysis section.
Comment	The relationship between the 8 am temperature data and the maximum daily and average temperatures needs to be clarified.
Response	The 8:00 am temperature was the only temperature data base available. Clarification has been provided in the temperature analysis section.
Comment	The TMDL must clarify the sediment target, link it to beneficial use support and explain how Washington State's turbidity standard will be met.
Response	This has been addresseds in the water quality standards and section.
Comment	The Idaho water quality standards for ammonia should be stated and shown that Washington's standard is as protective or more stringent than Idaho's.
Response	This has been addressed in the water quality standards section.
Comment	TMDLs which allocate a pollutant load between point and nonpoint sources must show reasonable assurance that the nonpoint source load reductions will be met or the point source will be required to meet the entire allocation.
Response	This has been addressed in the reasonable assurance section.
Comment	The TMDL should provide a clear description of the monitoring program that will be implemented to refine the TMDL and assess the water quality of Paradise Creek.

Response	The TMDL discusses additional monitoring needs in the data gap section. Additional specific details of the Paradise Creek TMDL monitoring plan will be developed during the development of the TMDL's implementation plan.
Comment	The origin of the information used in Tables 1, S1 and S2 needs to be clarified.
Response	This has been addressed in Appendix A.
Comment	The case for targeting phosphorus as the nutrient of concern needs to be provided.
Response	This has been addressed in the nutrient analysis section.
Comment	The TMDL needs to demonstrate that nutrients are not a year round issue.
Response	This has been addressed in the nutrient analysis section.
Comment	The TMDL must provide an explanation of why there are two load capacities for pathogens.
Response	A separate load capacity was developed for both the Washington State and Idaho State water quality standards for application on the Idaho side and compliance at the Washington border. The final load capacity been revised to reflect only the Washington State water quality standards applicable at the Washington border.
Comment	The University of Idaho aquaculture facility waste load needs to be clarified.
Response	This has been addressed in the load and allocation analysis section.
Comment	The document is too long and the format is difficult to read.
Response	The document has been edited for clarification and to reduce duplication.
Comment	The TMDL needs to acknowledge data uncertainties exist and revisions to incorporate additional data in the future are possible.
Response	The TMDL incorporates a margin of safety to address data uncertainties. Future revisions of the document and its contents are discussed in section 3.
Comment	The document lists the Watershed Advisory Group's concerns but it does not explain how they will be addressed.
Response	Most concerns expressed over the impact the TMDL will have are related to implementation activities. The TMDL does not require specific activities be implemented. It will be up to the WAG and the community to identify specific implementation actions.
Comment	The City of Moscow Wastewater Treatment Plant effluent should be addressed by utilizing a phased approach to mitigation rather than the DEQ's proposed set target of 98% removal. Phasing considerations should include planting to shade Paradise Creek to exclude sunlight, use of wetlands, and land application of effluent.

Response	The TMDL establishes loads to achieve water quality standards. The TMDL does not state how to achieve these loading goals.Thes are issues to be addressed by the Watershed Advisory Group during development of an implementation plan.
Comment	The time frame for discharge of effluent containing phosphorus should be May 15 through September rather than the proposed target of April through October.
Response	The critical season for light influenced algae growth in Paradise Creek has been determined to be between mid May and October. This new information has been incorporated into the TMDL.
Comment	Temperature limits should be measured at the Idaho/Washington state border rather than imposed on the effluent at the City of Moscow Wastewater Treatment Plant. This would allow consideration for the use of natural cooling and temperature mitigation methods and techniques, including the planting of trees and shrubs to shade Paradise Creek before it reaches the state border rather than constructing costly cooling devices at the waster water treantment plant.
Response	Point source temperature loading to a stream may increase the stream temperature near the outfall, then decrease as energy is dissipated by cooler ambient air or stream temperatures. However, a decrease in effluent temperature will only occur when the ambient air or stream temperature is less than the effluent temperature. In order to meet the target established at the state line at all times, it was assumed that no cooling occurs between the plant and the state line.
Comment	The TMDL limit of 15 mg/l for suspended solids in the City of Moscow Wastewater Treatment Plant effluent is more realistic than the 10 mg/l proposed by DEQ.
Response	The TMDL has been revised to reflect a 15 mg/l total suspended sediment target for the Moscow wastewater treatment plant.
Comment	The Washington state classification of Paradise Creek as Class A waters should be reviewed and revised. There needs to be a joint agreement between Washington and Idaho that water quality standards will be met by each state for the entire length of Paradise Creek
Response	The Washington State Department of Ecology is scheduled to review the Paradise Creek classification. Any changes in the Washington state classification will be reflected in the Paradise Creek TMDL after such changes are made.
Comment	EPA and DEQ should conduct a cost-benefit analysis of the proposed TMDL limits for Paradise Creek.
Response	The TMDL development process does not allow for a cost benefit analysis. The cost benefit analysis is more appropriate to be applied in the development and review of pollution control options during implementation of the plan.

Comment — Numeric targets developed for use in the TMDL should not be used as an end but rather as guidelines to demonstrate progress toward the goal of attaining beneficial uses. Beneficial uses are the final test of whether or not the TMDL and its implementation plan have been successful rather than water quality standards.

Response — TMDL targets are viewed as goal to work towards to attain full support of beneficial uses. Water quality standards are used to ensure beneficial uses are protected. Full support of beneficial uses includes adequate protection. Both beneficial use support and compliance with water quality standards is desired.

Comment — The target of 50 mg/l total suspended sediment is unattainable and scientifically unfounded.

Response — The sediment target contained in the Paradise Creek TMDL is 50 mg/l above background for 10 consecutive days. The target is based on a statistically significant correlation between total suspended sediment and the current Idaho water quality standard of 25 NTU turbidity for 10 consecutive days using data collected at the intersection of the Main Street Bridge in Moscow and Paradise Creek.

Comment — The total daily maximum load for sediment should be addressed in a narrative fashion and tied together with Best Management Practice application requirement levels with results required for achieving the beneficial use.

Response — The Idaho Nonpoint Source Program operates with such a goal in mind. However, a "narrative fashion" is inconsistent with EPA TMDL requirements.

Comment — The failure to address flow/habitat alteration issues in the draft is a fatal flaw in the document that subverts the otherwise generally outstanding effort of the WAG and DEQ to create a TMDL.

Response — The TMDL cannot address flow and habitat alteration in a calculated loading and load capacity analysis using measurement units of mass per time. Therefore the TMDL addresses flow and habitat alteration through implementation of corrective actions required for other quantifiable pollutants such as temperature, sediment and nutrients.

Comment — Targets in the TMDL need to be reinforced by specific and detailed reference to the supporting body of empirical data and studies.

Response — Targets in the TMDL are based on the Idaho Water Quality standards for full support of the designated and existing Beneficial Uses of Paradise Creek.

Comment — Recommend effluent phosphorus limits imposed on the Moscow wastewater treatment plant as part of the NPDES license be implemented in increments which allow for periodic analysis of such mitigation effects as riparian restoration proceeds along Paradise Creek.

Response	The NPDES permit program is managed by the USEPA. Permit limitations are generally established between the Permit program and the permitted facility. The TMDL simply establishes the in stream water quality target(s) for pollutant loading based on the allowable load capacity of the water body.
Comment	There is no temperature water quality target listed for the aquaculture facility, is this because the discharged water from the facility is colder than 18 C degrees?
Response	An 18 C degree temperature allocation has been applied to the end of the facility's discharge pipe.
Comment	Load allocations should be expressed according to flows at the Washington border not as loads at the Moscow Waste Water Treatment Plant.
Response	Waste Load Allocations are applied at the end of the facility's discharge pipe rather than at the state border because the low flows and existing loads within Paradise Creek does not allow assimilation of any additional loads in that section of the creek.
Comment	Technology based controls should be in place first before it can be determined if a water body is not in compliance with water quality standards.
Response	Paradise Creek is not in compliance with water quality standards based on monitoring and analysis of the water body.
Comment	Do Idaho Fish and Game or US Fish and Wildlife Service have any evidence of Brook Trout being stocked in Paradise Creek in the early 1900's?
Response	No evidence has been found.
Comment	We have not been shown that a TMDL is legally required by the Clean Water Act.
Response	This document reflects the Idaho TMDL process, it does not attempt to refute or question the legal background as to the validity of the state's program.
Comment	We are concerned that the end result of this document may become a templat for other mostly forested watersheds.
Response	TMDL are intended to address specific watershed problems. As such each TMDL will be effectively a stand alone document.
Comment	The document would be greatly improved if it were written as a scientific document with an exhaustive methodology section covering each step in the process with an estimate of reliability after each assumption.
Response	The Idaho TMDL process is not intended to provide academic or scientific research analysis of procedures. It is intended to provide the best determination of a water quality limited segment's pollutant load capacity, waste load allocations and load allocations with the information available.

State of Idaho Comments on the Proposed ESA Listing of Snake River Steelhead

IV. Current Management and Impacts on Recovery

a. Habitat: watershed initiatives, bull trout provisions, wilderness/limited use areas, forest plans, grazing plans, etc. Areas of direct and indirect State authority. Current status, assumed impacts, planned changes.

NMFS recognizes that state and local efforts are the key to successful salmon and steelhead restoration and any listing decisions under the Endangered Species Act need to give meaningful state and local efforts serious consideration. NMFS should carefully review Idaho's existing watershed management and protection programs in Idaho before making a final listing determination.

1. Watershed Initiatives

The State of Idaho has adopted an integrated "Watershed Approach" to managing and protecting it's land, water, fish and wildlife resources. Included in this approach is an emphasis on community-based problem-solving. Resource managers recognize the value and importance of developing partnerships with federal, local and tribal governments and private landowners to share common goals for managing watersheds and protecting aquatic ecosystem health.

In 1995, the Idaho Legislature passed a comprehensive amendment to the Idaho Code (§39-3601 et seq.) restructuring the administration of water quality laws in the state and strengthening water quality protection to improve compliance with the Federal Clean Water Act. This new water quality legislation represents the framework for Idaho's watershed management and protection program.

An important component of the watershed management program is establishing community-based citizen advisory committees in each of the six major river basins and high priority watersheds. With technical support of state and federal agencies and private industry, basin advisory groups (BAG's) and watershed advisory groups (WAG's) are establishing basin-wide priorities and recommending protection measures necessary to address resource-related problems within designated watersheds and basins. The BAG and WAG processes are designed to complement and integrate existing watershed management efforts throughout the state.

A good example of Idaho's watershed management capabilities can be seen with the Idaho Soil Conservation Commission's (ISCC) model watershed projects. The ISCC, in cooperation with state, federal and tribal resource management agencies and private landowners is overseeing the implementation of model watershed projects in both the Clearwater and Lemhi River subbasins. With the funding support of the the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program, model or focus watershed projects are designed to be a cooperative, non-regulatory watershed management strategies for protecting, enhancing and restoring anadromous/resident fish habitat and water quality.

In particular, these comprehensive watershed management programs have begun to identify limitations and omissions in existing programs/laws; identifying limiting factors for anadromous and resident fish productivity; selecting priority watersheds and watershed actions for water quality and habitat protection or improvement; drafted treatment actions to address fish habitat and water quality concerns; and coordinating all human and financial resources necessary to successfully implement habitat protection and enhancement. The lessons learned from implementing these projects is fully transferrable to other high priority watersheds recommended for protection.

The State of Idaho also participates in regional watershed-based approaches including the Columbia Basin Watershed Restoration Team coordinated by the Columbia River Inter-Tribal Fish Commission. The purpose of this restoration team effort is to integrate salmon recovery plans among federal, state and tribal interests and addresses salmon subregional recovery priorities in terms of habitat restoration and fish production. The Team is currently preparing a multi-year workplan outlining salmon recovery goals and identifying additional players and partnerships essential to the development and implementation of a subregional 'strategy and watershed action plans.

2. Bull Trout Plan

In July 1996, Governor Philip E. Batt issued a Bull Trout Conservation Plan for Idaho which will result in the development and implementation of recovery plans for 59 "key" bull trout watersheds. These high priority watersheds were identified for having the greatest potential for protecting and restoring bull trout populations. The plan emphzasizes the need to protect healthy populations of bull trout while instituting recovery strategies which will result in a measurable improvements to their status, abundance and habitats.

A primary component of the Bull Trout Conservation Plan strategy is forming bull trout watershed advisory groups to develop and implement locally developed common sense protection and restoration measures for watershed specific conditions. While bull trout is the target species, many other aquatic and terrestrial species (e.g. steelhead) will also likely benefit from these conservation actions. The Plan presents an ambitious schedule for completing all recovery plans within the state before January 1, 1999. This includes conducting comprehensive assessments for each key watershed within the next two years and completing of a minimum of six watershed recovery plans each year.

3. Federal Habitat Management and Protection

Approximately 69% of the Lower Snake River Basin is comprised of lands within jurisdiction of the federal government (e.g. United States Forest Service and the Bureau of Land Management). As such, federal land management and watershed protection plays a prominent role in watershed management and protecting anadromous fish habitat quality in Idaho.

Large areas of anadromous fish in Idaho are included within designated wilderness or wild and scenic river corridors. The Selway-Bitteroot, Frank Church River of No Return, Gospel Hump, Hells Canyon, and Sawtooth wilderness areas each contain significant steelhead habitat. Together, these areas comprise approximately four million acres. In addition, there are approximately nine million acres of recognized roadless areas on U.S. Forest Service land in Idaho.

Designated wild and scenic rivers include: Lochsa, Selway, Middle Fork Clearwater, Middle Fork Salmon, Main Salmon and Rapid River. Approximately 31% of Idaho stream miles inhabited by steelhead are in wilderness or wild and scenic river status (Groen 1990).

Each of the seven national forests and the Bureau of Land Management have land management plans prescribing mandatory standards and guidelines for the protection of fish habitat. In particular, PACFISH is the USFS and BLM interim strategy for managing anadromous fish-producing watersheds in Idaho. PACFISH establishes riparian goals which provide a set of characteristics for healthy, functioning watersheds, riparian areas, and associated fish habitats. The goals provide an outline of ecological processes and functions under which aquatic and riparian ecosystems developed and anadromous fish populations evolved. Implementing PACFISH guidelines on federal lands in Idaho ensures that fish and their habitats are equally protected and restored (NMFS 1995).

4. Direct and Indirect Authorities

Under the federal Clean Water Act (CWA), the state has the responsibility to set standards against which success in meeting the goals of the CWA can be measured. Inherent in the standard is the concept of beneficial uses. The biological or consumptive use depends upon the quality of the water or aquatic values for each stream or waterbody. Idaho's general water quality standard requires protection measures sufficient to support all beneficial uses, including cold water biota and salmonid spawning or rearing. Beneficial uses which are protected and fully supported meet both the narrative and quantitative water quality criteria contained in the standards.

The Idaho Water Quality Standards and Wastewater Treatment Requirements also ensure that the waters of the state are protected from unauthorized dredging, discharge of fill material, draining, ditching, diverting, blocking, or altering stream channels or surface or ground water flow. These standards also protect against discharges of toxic chemicals or other pollutants (e.g. sewage, oil and gasoline).

Idaho also has legislation protecting salmonid spawning and rearing beneficial uses from the adverse impacts of mining land use with the Idaho Surface Mining Act, the Dredge and Placer Act, and Ore Processing by Cyanidation standards. These acts and implementing regulations require miners to submit mine reclamation plans and obtain permits ensuring compliance with Idaho's water quality standards. These rules contain detailed technical requirements and apply to state, federal and private lands.

Monitoring and reporting are necessary components of any watershed management program to ensure that standards and guidelines are being implemented and that progress is being made toward achieving ecological goals. In 1993, Idaho embarked on a Beneficial Use Reconnaisance Project (BURP) aimed at integrating biological and chemical monitoring with physical habitat assessment as a way of characterizing stream integrity and the quality of water. The objectives of this monitoring program are to determine beneficial use attainability and use support status, including characterizing reference stream conditions (IDHW-DEQ 1996).

To date, Idaho has conducted BURP monitoring on approximately 900 streams and the goal is cover all waters of the state on a five year monitoring cycle. The water quality and biological monitoring data collected during the BURP process will be assessed using a standardized Water Body Assessment Guidance process (IDHW-DEQ 1996a.). The results of this monitoring and assessment is being used at the basin and watershed level by managers and advisory groups to develop water quality management priorities and to make knowledgeable decisions.

The Idaho Forest Practices Act (FPA) maintains minimum standards by which forest practices can occur in Idaho. One of the purposes of the act is to protect and maintain the forest soil, air, water resources, wildlife and aquatic habitat. The rules of this act apply to all state, private and federal lands where forest practices occur. If followed, this act has proven effective in maintaining stream water quality. The rules of this act can be effectively enforced because violators can not sell timber in Idaho. In addition, yearly audits continually evaluate whether the FPA protects and maintains aquatic habitat. The results of a 1993 forest practices audit indicate management practices were used in the majority of cases and were judged to effectively prevent pollutant delivery to streams (IDHW-DEQ 1994).

Idaho also has a Cumulative Watershed Effects (CWE) process to determine if an accumulation of individual forest practices will combine to have negative impacts on aquatic environments. This process looks at instream as well as upslope characteristics and will be used to determine current stream conditions, effects of future activities, and proper management strategies. Findings during this process will be used to ensure watersheds are being managed to protect water quality and support beneficial uses. This process is currently being used on forested lands, but it is feasible that it can be incorporated with a monitoring process to address other watershed management issues in the future.

This above-mentioned list of rules, regulations and watershed management tools is not comprehensive. NMFS should seek additional information from state, federal and tribal, and industrial land resource managers regarding specific habitat quality protections and programs.

Other watershed programs to consider in this section?

IDWR State Water Plan
Agricultural Water Quality Program
Nonpoint Source Management/319 Program

5. Current Status and Assumed Impacts

Snake River summer steelhead spawning and rearing habitat in Idaho consists of approximately large portions (i.e. 4,500 miles) of the Salmon and Clearwater basins as well as the Snake River between Hells Canyon dam and the head of lower Granite pool. These areas are characterized by steep mountainous terrain with relatively low population density. Water quality in these areas is considered good (IDHW-DEQ 1994) and anadromous fish habitat quality has not been signficantly altered or degraded. The fact that 31% of Idaho's anadromous spawning and rearing areas lie within federal wilderness areas is strong evidence of habitat protection.

Habitat quality parameters necessary to support spawning and rearing beneficial uses include suitable gravel for spawning, large cobble for hiding space for fry and parr, holding areas and pools, and riffles for growth of aquatic insects and other organisms. Riparian zones are also important and serve to moderate water temperatures and runoff, contribute large organic debris, and trap sediments eroding from adjacent lands.

While much of the salmon and steelhead spawning and rearing habitat in the Columbia River Basin is in good condition (ACOE 1994), information derived from the Idaho Rivers Information System (IRIS) and the smolt modeling database indicates that 75% of Idaho's steelhead fish habitat could support a level of smolt production considered to be very high to excellent (IDFG 1990). Specifically, in the Salmon River basin, 72% of steelhead habitat (i.e. 2,926 miles) was found to support steelhead smolt production that was very high and considered excellent. In the Clearwater River basin, 61% (i.e. 1,487 miles) of the steelhead habitat quality was capable of supporting a high level of smolt production.

6. Habitat Management Goals and Planned Changes:

Idaho's watershed management and conservation strategies represent a signficant and comprehensive effort to protect anadromous fish habitat and to conserve aquatic ecosystem health. An ecosystem-based watershed approach, as is presently being implemented under the new water quality legislation, is necessary to ensure that all physical, biological, and chemical processes and conditions that contribute to the development of productive steelhead habitat are maintained.

Idaho intends to continue applying existing watershed management and protection programs to meet cur anadromous fish habitat goals. Ultimately, the recovery of wild and natural stocks of Snake River summer steelhead will depend principally upon ameliorating passage problems in the mainstem Snake and Columbia Rivers (NMFS 1995). Based on information currently available, the production potential of Idaho's anadromous fish habitat is not being met due to high migration mortality, therefore, spawning and rearing habitat is not a constraining factor. Idaho's current habitat protection programs are adequately providing for Snake River summer steelhead survival and recovery.

Steelhead Protection Strategy?

REFERENCES

Bauer, S.B. 1989. Idaho Nonpoint Source Management Plan: 1989. Idaho Dept. of Health and Welfare, Division of Environmental Quality, Boise, Idaho. 136 pp.

Groen, C. 1990. December 13, 1990 Memorandum from Idaho Department of Fish and Game Program Coordinator Cal Groen to Andy Brunelle, Office of the Governor re: Anadromous Fish Information Request. Idaho Department of Fish and Game, Boise, Idaho. 3 pp.

Idaho Department of Fish and Game. 1992. June 9, 1992 Staff Report re: Technical Background Supporting Idaho Spawning and Rearing Habitat Condition Statements and the Role of Habitat in Salmon Recovery (unpublished). IDFG, Boise, Idaho. 7 pp.

Idaho Dept. of Health and Welfare, Division of Environmental Quality. 1994. Idaho Water Quality Status Report. IDHW-DEQ, Boise, Idaho. 141 pp.

Idaho Department of Health and Welfare, Division of Environmental Quality. 1996. 1996 Beneficial Use Reconnaisance Project Workplan. IDHW-DEQ, Boise, Idaho. 70 pp.

Idaho Department of Health and Welfare, Division of Environmental Quality. 1996a. 1996 Water Body Assessment Guidance: A Stream to

Standards Process. IDHW-DEQ, Boise, Idaho. 109 pp.

Independent Scientific Group. 1996. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem (prepubication copy). Northwest Power Planning Council, Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, Oregon. 580 pp.

Snake River Salmon Recovery Team (SRSRT). 1993. Draft Snake River Salmon Recovery Plan Recommendations.

State of Idaho, Office of the Governor. 1991. State of Idaho's Comments on Critical Habitat Designation For Snake River Sockeye and Spring, Summer, and Fall Chinook. State of Idaho, Office of the Governor, Boise, Idaho. 18 pp.

State of Idaho, Office of the Governor. 1996. Governor Philip E. Batt's State of Idah Bull Trout Conservation Plan. State of Idaho, Office of the Governor, Boise, Idaho 112 pp.

U.S. Army Corps of Engineers. 1994. Columbia River System Operation Review, Appendix C-1: Anadromous Fish. U.S. Army Corps of Engineers, Portland, Oregon.

U.S. Department of Commerce, National Marine Fisheries Service. 1995. Proposed Recovery Plan for Snake River Salmon. USDC-NMFS, Seattle, Washington. 382 pp.